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JUNE 1920

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THE

JOURNAL
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AUTOMOTIVE ENGINEERS

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J. G. VINCENT, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. VI June, 1920 No. 6

The Summer Meeting

THE plans for the 1920 Summer Meeting of the Society to be held at Ottawa Beach, Mich., June 21 to 25, are, as a result of the faithful and close attention of the Meetings Committee, very well advanced. The five days will be replete with interesting professional sessions as well as opportunity for recreation and sports. It is expected that the great majority of the members will arrive on Monday morning in time for the Standards Committee Meeting at 10 o'clock and arrangements are being made for special train accommodations to this end. In addition to the Standards Committee program on the first day, the sports events will be started including tournaments in tennis and golf, besides the opening game in the championship baseball series between Sections of the Society. The Society Business Session will be held on Monday evening, when matters of unusual importance to the welfare of the Society will be taken up. The members are requested to consider carefully the proposed constitutional amendments described in the January and April issues of THE JOURNAL, in order that thorough discussion may be given the matter before the final ballot is taken. It is desired also that the members inform themselves prior to the meeting on the various matters involved in the metric system agitation, so that the discussion of these at the meeting shall be as thoroughly representative as possible.

Transportation Arrangements

The Lehigh Valley and the Grand Trunk Railroads are prepared to give special service to the members and their guests in connection with the meeting. Special trains will be run consisting of combination baggage-buffet-club car, combination observation car and the necessary standard Pullman cars together with such compartment and drawing-room accommodations as may be necessary. Dining cars will be available for the serving of all meals en route including breakfast on Monday morning.

A train is scheduled to leave the Pennsylvania Station, New York City, at 9:30 a. m., daylight saving time, Sunday, June 20. Special Pullman cars for the Pennsylvania members will leave Reading Terminal, Philadelphia, at 9:15 a. m., Eastern standard time, joining the special train at South Bethlehem. The special cars for the Buffalo members will be made up in Buffalo and be attached to the train Sunday evening. This train will arrive in Grand Rapids, Monday, at 7:30 a. m., Central standard time.

Special cars will be run over the Michigan Railroad (electric) from Grand Rapids to the Interurban pier at Macatawa. These cars will leave Grand Rapids at 8:00 a.m. All necessary arrangements will be made by the Lehigh Valley Railroad for transportation of passengers between the Grand Trunk Terminal and the electric railway in Grand Rapids. Baggage can be checked through to the Hotel Ottawa, the railroad holding itself responsible for the prompt and safe arrival of the baggage. It is understood that a representative of the Lehigh Valley Railroad or of the Grand Trunk Railroad or both will accompany the members.

A minimum of 125 adult fares is required for special train service. In the event of a less number a second section of the Black Diamond Express will be run. Baggage can be checked through to Ottawa Beach in either event.

Professional Sessions

The Professional Sessions of the Society will begin on Tuesday morning, when papers dealing with fuels will be presented. These will bring out many points relative to engine design and fuel economy. Dr. H. C. Dickinson will have as a subject, Engine Power and Economy Tests. This paper will be based upon tests run at the Bureau of Standards under the direction of Dr. Dickinson, the results of which will indicate the relative value of some methods by which both power and economy in engine operation can be obtained. This paper will be closely connected with the S. A. E. Committee report on More Efficient Utilization of Present Fuel. After much study and deliberation, the results of the committee's investigation will be given the members in the form of a report which probably will have great influence on engine design. There will be a symposium on the subject of engine design for maximum power and fuel economy by H. M. Crane and other engineers well qualified to discuss refinements of engine design.

The Transportation Session on Wednesday morning, the 23rd, with President Vincent in the chair, will deal with the subjects of water, air and highway traffic. A paper on Highway Transportation by Col. G. A. Green, giving statistics and interesting engineering data concerning bus operation, based upon the experience of this engineer who has done considerable pioneer work in this field, is scheduled. F. W. Davis will describe the work of the S. A. E. Committee on Science of Truck Operation. This committee is confronted with a great amount of important investigation and through a clearer understanding of its proposed procedure, greater possibilities of cooperation and effectiveness will result in all directions. Highway engineers, it is expected, will

discuss problems of modern highway construction and maintenance, presenting engineering statistics and other important phases of road economics. Inland waterway transportation, which is assuming more and more importance in view of the limited rail equipment and difficulties in rail transportation, will receive adequate attention. All that can be recorded of air navigation is far from having become generally known. The problems perplexing aeronautical engineers will be discussed in a paper dealing with air passenger and freight transportation.

The Farm Power Session, Thursday, June 24, E. A. Johnston presiding, will consist of papers by Major O. B. Zimmerman on Analysis of Tractor and Plow Operating Factors, and by Percival White, Jr., who will review the subject of The Operating Speeds of Agricultural Implements. These papers will provide opportunity for frank and full consideration of the high-speed plowing tractor and tractors hauling plows in multiple. A paper entitled, Notes on Farming, will be presented by R. W. Lohman. It is based upon his experiences in the operation of the farm machinery employed on one of the largest farms in the world at present under cultivation. It will afford a basis for discussion mutually beneficial to the automotive and the agricultural engineer. A large amount of engineering data dealing with farm power machinery, some of which will be unique, will be presented. The important factors involved in tractor rating and the immediate necessity of tractor rating formulas will, in addition, be discussed by several engineers.

The Production Session on Friday, with Harold Emmons presiding, will be of great value to production engineers in view of the fact that production problems have seldom been more acute than at the present time. There is necessity for cooperation on the part of the production men. For this meeting papers have been obtained from engineers on subjects of distinct importance. A. G. Drefs will deal with Production and Control Systems of Accounting in Connection with Shop Production. The Human Element in Production will be discussed by A. F. Knobloch. Magnus W. Alexander will deliver an address on Factory Organization, placing special emphasis on the selection and training of personnel. The session will be of marked interest to all executives engaged in the manufacture of automotive vehicles and appurtenances.

COMMITTEE ON SCIENCE OF TRUCK OPERATION

MANY committees have been appointed by various organizations to take up matters connected with the construction and maintenance of highways, and those in the automotive industry interested in the production and operation of passenger cars and more particularly motor trucks have naturally taken part in the establishment of suitable laws and systems in the connection. President Vincent and the other members of the Council have been considering for some time the demand for the appointment of a committee of representative motor-truck engineers to supply first-hand information on the problems confronting the manufacturer as well as the user. As was pointed out repeatedly by Past-President Manly in his addresses, the engineering phases of motor-truck operation are as important as those of design and production.

President Vincent has appointed at the request of the Council the following Committee of the Society:

F. W. Davis, chairman, Pierce-Arrow Motor Car Co.
M. C. Horine, International Motor Co.
V. Z. Lane, Hare's Motors
E. E. Wemp, Graham Bros.
C. M. Manly

This committee will investigate matters of which there is scattered knowledge today, including such topics as the relation between road cost and truck operating, effect of roads and grades on cost of operation, truck size and body design from the economic standpoint, the relation between cost of loading and of operation and overloading and overspeeding from the economic standpoint. The work of the committee will be correlated with that of the Highway Economics Committee of the Engineering Division of the National Research Council, Past-President Manly being a representative of the Society on the latter committee. The Society Committee will also cooperate with the National Automobile Chamber of Commerce in the matter of establishing courses in highway engineering and highway transportation at schools and universities with a view to better meeting modern conditions, including vocational training of skilled labor in the fields indicated. At the meeting on this general question held at the Michigan Union, Ann Arbor, Mich., recently, Chairman Davis of the committee represented the Society.

At the conference at Ann Arbor on April 15 the crying need for highly-trained engineers capable of dealing with the problems of highway construction and transportation was emphasized. It was pointed out that the employment of men technically educated in highway construction work would benefit not alone the automotive industry but also the entire country. More information of an authentic character on the construction and maintenance of roadways, including a knowledge of the proper soil conditions to permit comprehensive road building was stated to be very necessary. The economic principles of highway transportation and the ways and means to secure the necessary trained personnel to direct the construction of the highways and the operation of motor vehicles over them in addition to taking an active part in the design of these vehicles were also discussed at some length. All of those present at the conference expressed their belief in the importance of the various subjects brought up and stated the willingness of the interests which they represented to help.

GENERIC NAME FOR INDUSTRIAL TRUCKS AND TRACTORS

THE Industrial Truck and Tractor Subdivision of the Electric Transportation Division has given considerable study to the derivation of a generic name covering industrial trucks and tractors. The need for such a name for use in referring to industrial trucks and tractors used extensively in industrial plants for handling material between departments has been keenly felt. In practice it has been found that nicknames have been given to the trucks used, which in some instances has created confusion.

The Subdivision has suggested the use of the word tructor, a combination of the words truck and tractor. It was, however, felt that a better name could be derived if the subject were given more careful consideration and it was therefore suggested that a prize of $25 should be offered to whoever submits the best generic name which would cover industrial trucks and tractors.

As the next meeting of the Subdivision will probably be held in the early fall it is suggested that any suggestions in this connection should be sent in to the Society office at an early date.

The Use of Aluminum in the Present and the Future Motor Car

By FERDINAND JEHLE[1] (*Member*)

CLEVELAND SECTION PAPER *Illustrated with* PHOTOGRAPHS AND DRAWING

ALTHOUGH aluminum is the most abundant metal in the earth's crust, it was not until the early eighties that means were discovered of reducing it from its ores in such quantities and at such a price as to make it a commercial possibility. The world immediately began to find uses for this material. A. E. Hunt, president of the Pittsburgh Reduction Co., in an article entitled Aluminum, Its Manufacture and Uses from an Engineering Standpoint, which was published in the *Journal of the Franklin Institute* in 1892, states

> In recent years two groups have developed: (*a*) Those who, assuming properties for aluminum it did not possess, thought that it would in time replace all other metals, and (*b*) those who, reacting from the first view, due to failures and disappointments, thought it had little use

It is surprising that some of the hopeful ones did not propose to mold up the clay banks into buildings and railroads and turn on the electric current and produce aluminum structure in situ. It did not take many years for the condition to change. Those who thought that the whole aluminum question had been settled soon began to realize that much investigation and research were necessary to make aluminum a really commercial metal, and those who thought that it had little use saw their error.

In 1896 the *Horseless Age* published an article entitled Aluminum in Motor Vehicles, which is so interesting that I shall quote from it.

> The horseless age is fortunately contemporaneous with the age of aluminum and this latest discovery in the metal industry is likely to play an important part in the development of the motor-vehicle industry. Lightness and strength combined are the great desideratum in metal vehicle construction and as aluminum alloys weigh only one-third as much as iron of the same bulk, it will be seen that the metal is admirably adapted for the purpose

The interesting fact in connection with this article is that it appeared in one of the very early issues of the first technical automobile paper in the English language. At the time of its publication it was undoubtedly considered a prophecy, but today we know that it is quite true. One of the main aims of the automobile engineer is to obtain lightness combined with proper strength. This is clearly shown by many papers and expressions of opinion in the *Transactions* of our own Society. At all meetings at which papers on the Ideal Car, or similar subjects such as the Symposium on the Future Passenger Car, were presented and discussed by the membership, as at the last Summer Meeting, the one thing generally common to all discussions and papers is that lightness is desirable. It is very true that the different speakers would lighten cars by various methods, some by using a light-weight wood construction, others by employing pressed steel and some by the more extended use of aluminum alloys. This paper deals with the last-named method.

PHYSICAL PROPERTIES

In the early period of aluminum, its use was considerably hampered by its lack of strength. The tensile strength of pure aluminum is about 13,000 lb. per sq. in. Since this is not enough, alloying with other metals, such as copper, was resorted to. The tensile strength of aluminum alloys was at first very uncertain. That of the well-known No. 12 alloy has been given for a number of years as 20,000 lb. per sq. in. In standard test-bars this figure was obtained, but in regular production it could not be relied upon. Even during the war it was not found possible to hold all foundries to this figure and the Liberty engine specifications had to be lowered to 18,000 lb. per sq. in. For many purposes this strength is sufficient. Without question it was the uncertainty of meeting any specifications that was responsible for limiting the use of aluminum alloys to parts that were not subjected to the highest stress. We therefore find aluminum used only for ornaments, cover plates, oil-pans and similar articles, for many years. Considerable time was, of course, required for those interested to realize that the handling of the metal in the foundry was quite as important as the composition of the alloys. Then technical control of melting and pouring, as well as of mixture, was installed in certain well-organized foundries. Nor would the control of these important factors guarantee results if pattern equipment were not suitable. Morris Percheron in an article in *L'Aerophile* entitled The War's Influence on Aeronautical Construction in Europe and America, under the heading of aluminum castings says

> American engineers have actually made a science of aluminum casting, where success today is based on the disappointments met with at the outset, great progress having been made if one compares the first foundry experiments with the complicated work of today. The "chance" method of casting does not lead to the production of sound pieces either in general or particularly in the casting of aluminum, and herefrom ensues the great variety in the quality of castings

With adequate technical control in our foundries, 20,000 lb. per sq. in. can be obtained and maintained in the straight copper-aluminum series of alloys in which No. 12 is classed. If this figure can be relied upon, it is entirely suitable for automobile engine parts that have commonly been made of aluminum heretofore, including oil-pans, crankcases and even cylinder blocks. A tensile strength of 20,000 lb. per sq. in. is, however, not sufficient for many purposes, and stronger alloys are now available. In this connection I refer to a product of our laboratories. It represents the result of exhaustive research of both the aluminum-copper and aluminum-cop-

[1]Dynamical engineer, Aluminum Manufactures, Inc., Cleveland.

per-zinc series. Later in the paper this will be discussed more in detail.

Tensile strength is not the only physical property of importance in motor-car construction. If the material is to be used for any structural purpose, it must have rigidity. The rigidity depends upon the modulus of elasticity which for aluminum alloys is 10,000,000 while that for cast iron is 20,000,000 in round numbers. This means that with a cast-iron and an aluminum-alloy beam of the same dimensions, it will take twice the load to deflect the former that is necessary to deflect the latter an equal amount. If we stop our comparison at this stage, we shall immediately decide against the use of aluminum alloys as a structural material. We must not forget, however, that the iron beam weighed approximately two and one-half times more than the aluminum one. Let us see what results we obtain by making both beams of the same weight and by distributing the metal so as to gain the greatest possible advantage. This would naturally mean that we make the aluminum beam two and one-half times deeper than the cast-iron one. The deflection varies inversely with both the modulus of elasticity and the cube of the depth. Therefore, the deflection of the aluminum beam is to the deflection of the cast-iron beam as $20{,}000{,}000 \times 1^3$ is to $10{,}000{,}000 \times 2.5^3$. We thus find that the deflection of the cast-iron beam is practically seven times that of the aluminum-alloy beam. Inversely, the aluminum-alloy beam is seven times more rigid than the cast-iron one.

We now determine how heavy the aluminum-alloy beam must be made to be as rigid as the cast-iron one. If D = the depth of the aluminum-alloy beam and the depth of the cast-iron one be taken as unity, along the line of reasoning already stated, we get

$$\frac{20{,}000{,}000 \times 1^3}{D^3 \times 10{,}000{,}000} = 1, \text{ hence}$$

$$D^3 = 2.00, \text{ or}$$

$$D = 1.26$$

The aluminum-alloy beam will be about one and one-fourth times deeper than the cast-iron one. It will weigh $1.26 \div 2.50$ or approximately one-half as much as the cast-iron one. We therefore get just as much rigidity from an aluminum-alloy structure as we do from a cast-iron structure at one-half the weight, provided the metal is distributed correctly. Bearing this in mind, there is certainly no better way of lightening engine crankcases than by making them of aluminum alloys. In doing so great attention must be paid to the proper distribution of the metal. Too often the problem of material and material distribution is not given proper consideration when the layout is first made.

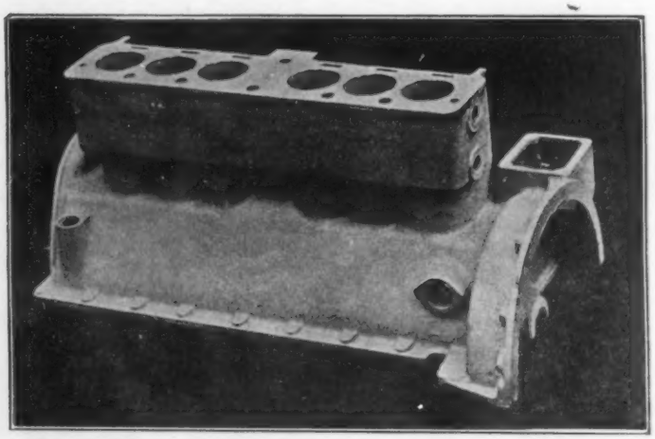


FIG. 1

The ductility or the elongation of a material is sometimes of importance. The percentage of elongation for cast iron is very low, being approximately ½ per cent. The ordinary casting aluminum alloys have an elongation of about 1½ per cent, whereas certain recently developed alloys run as high as 5 per cent without any reduction in tensile strength. This, of course, is decidedly an advantage over cast iron.

Strength, ductility and rigidity are not the only requirements of a metal, especially one that is to be used in a gasoline engine. An internal-combustion engine is a heat engine and one of its duties is to waste as efficiently and as easily as possible that heat which cannot be turned into power. A metal with a high heat conductivity is therefore desirable. The conductivity of aluminum at ordinary temperatures is about three times as great as that of cast iron. This at once recommends a material for such parts as oil-pans and water-jacket walls. At first it would seem that if a piston or cylinder-head, for example, were made out of a material having a high heat conductivity, large power losses would be brought about. It so happens, however, that the skin resistance or surface resistance to heat is about the same for all metals. The heat-flow into the piston or cylinder-head is therefore largely determined by the exposed area. Having once entered these parts, the heat is more

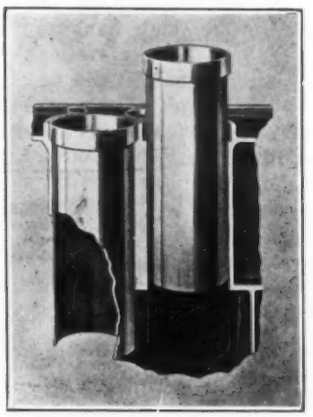


FIG. 2

rapidly conducted out of them, in cases where the parts are made from the material having a high heat conductivity than if they are made out of a metal having a low heat conductivity. We have reason, therefore, to believe that an aluminum piston or cylinder-head will stay cooler than an iron one. That the temperature actually is less in the former case than in the latter is borne out by the fact that less carbon trouble above and below the piston and less trouble with self-ignition are encountered. To answer the requirements of strength at high temperatures, special alloys have been developed for pistons, and still others for such parts as cylinder-heads, in both of which cases the ordinary No. 12 alloy would not be desirable.

VARIED USES

In 1913 a large manufacturer built thirty engines with aluminum cylinder-blocks. These were painted black so that they could not be distinguished from cast iron and sold as the regular product. The operation of these en-

gines was not different from the regular product and some of them are still running. I conducted more or less elaborate tests on one of these engines and on a similar one built entirely of cast iron. Accurate measurements of the heat losses were made and no differences in these losses were discovered. It is reasonable to expect, however, that in the case of an engine in which the entire combustion space is made of aluminum a somewhat higher compression pressure could be used. Fig. 1 shows this cylinder-block and Fig. 2 the method of inserting the cast-iron sleeves in which the pistons operated. A few years after these thirty engines had been built, another company came out with an engine constructed almost entirely of aluminum. This was the first commercial all-aluminum engine. Shortly afterward a third company placed on the market an engine of similar construction. Both of these engines utilized cast-iron cylinder-liners. These were installed similarly to the method shown in Fig. 2. Later the aluminum was removed from around the cast-iron liners, thus allowing the water to come directly in contact with the cylinder wall. This method of installing is shown in

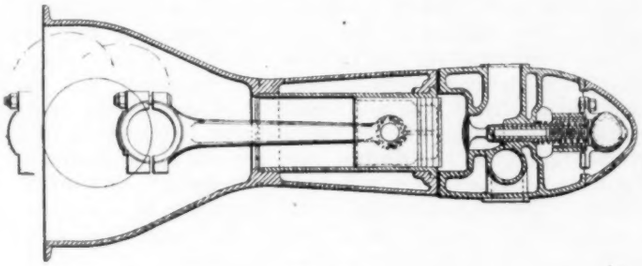


FIG. 3

Fig. 3. Fig. 4 shows an engine that was designed at our laboratories, involving a large use of aluminum alloys. The parts made of aluminum are indicated by letters and named in the list below.

A history of the use of aluminum in gasoline engines would not be complete without mentioning the Liberty engine. Although this is an aviation engine, I will mention a few interesting comparisons. In this engine 225 lb. of finished aluminum alloys is used. The finished engine weighs about 825 lb. The percentage of aluminum is, therefore, about 27. If all these parts were to be replaced with parts made of cast iron, they would add approximately 325 lb., making the engine weigh 1160 lb. There can be no doubt as to the advantage of reducing the weight of an aviation engine by an amount equal to that just mentioned and, generally speaking, weight reduction is as important in an automobile engine as it is in an aviation engine.

The use of aluminum alloys in motor-car construction need not be limited to the engine. It is quite as important that other parts of the car be made as light as possible. We find today that, due to recent alloy developments, this material can be used to advantage also in transmission cases, differential and worm-gear carriers, fans, radiator headers and shells and a great variety of other places. My company alone makes castings for something like seventy different parts used in motor-car construction. This includes cast aluminum bodies, which require still another type of alloy capable of being cast in thin sections of large area and embodying toughness and ductility. Cast aluminum has certain advantages as a body material. It is light, strong and presents a hard surface for finishing. Fig. 5 shows a cast aluminum body complete with the exception of upholstering and paint.

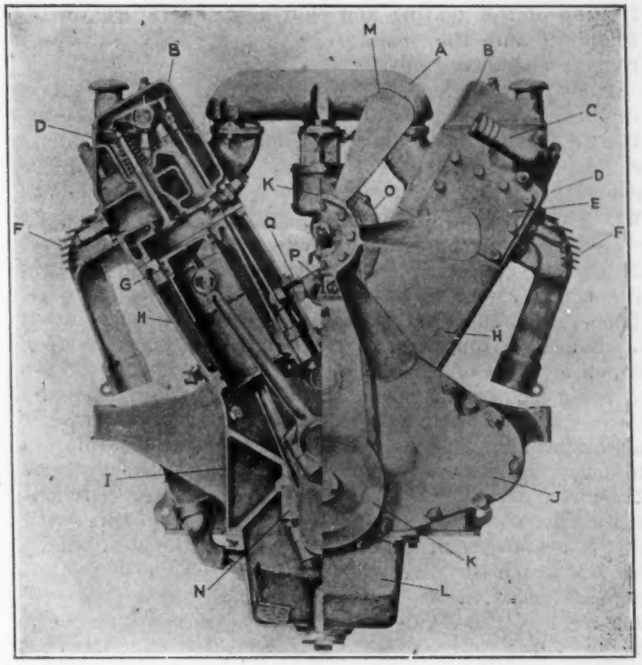


FIG. 4

A—Intake Manifold
B—Cylinder-Head Cover
C—Cylinder Water Outlet Elbow
D—Cylinder-Head
E—Cylinder-Head End Cover
F—Exhaust Manifold
G—Piston
H—Cylinder
I—Crankcase
J—Timing Gear Cover
K—Fan Pulley
L—Oil Pan
M—Fan
N—Crankshaft Bearing Caps
O—Water-Pump
P—Fan and Water-Pump Bracket
Q—Cylinder Water Inlet Elbow and Tee

RECENT DEVELOPMENTS

I shall now take up the different developments made in the old and the new alloys and in their use within the last few years. These developments may be divided into three main divisions.

(1) Development of new and better methods for handling old alloys
(2) The production of new alloys
(3) A study of the design of parts to adapt them to the use of aluminum

Progress along the lines coming under the first division has already been discussed. They include the con-

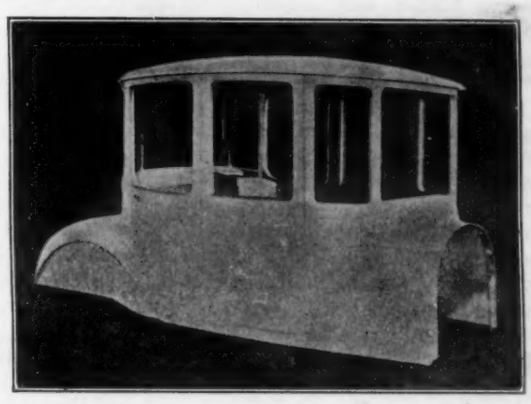


FIG. 5

trolling of the melting and pouring temperatures in the foundry, and the making of routine physical tests, routine chemical analyses, etc.

Alloy development has progressed to a large extent in the last few years. Having arranged foundry practice so that a physical specification of the existing alloys could be continuously met, it was only natural that our energies should be turned toward creating new alloys which would meet different requirements. As previously stated, an aluminum alloy having a tensile strength of 20,000 lb. per sq. in. can be used for nearly all purposes for which cast iron is used, so far as strength goes. There are many parts, however, which are today made of malleable iron, steel castings and mild carbon steels, which an alloy of this strength could not replace. Many of these parts could advantageously be made lighter and to accomplish this it was necessary to develop a stronger aluminum alloy. The alloy developed by our laboratories to meet these requirements has a tensile strength of 27,500 lb. per sq. in., an elongation of 4.5 per cent and an impact value of 1.96 ft.-lb. Comparing this with the values for another alloy similar to the well-known No. 12, which has a tensile strength of 20,000 lb. per sq. in., an elongation of 1.5 per cent and an impact value of 0.76 ft.-lb., it is evident that much progress has been made. All these increases are at the expense of increasing the weight from 0.103 to 0.106 lb. per cu. in. I feel that this alloy represents the best that can be done with either the aluminum-copper or aluminum-copper-zinc series.

I advise caution against misinterpretations of the figures given. We must not take the 37.5 per cent increase in tensile strength to mean that we can reduce the sections of the castings by that amount. Thinness of sections is generally limited by the ability to cast them and, for the time being, the thickness of castings is generally as small as it is commercially possible to produce. A stronger alloy, therefore, means an extension of the use of aluminum to parts that could not formerly be made of this material, rather than that existing parts can be made very much thinner. Again, strength is not the only requirement. While both of the alloys already mentioned retain their strength at ordinary temperatures, at the higher temperatures this drops off rapidly. Another alloy is therefore necessary for such parts as pistons and the like which are subjected to high temperatures. We have developed and used for several years an alloy that will withstand higher temperatures. Its strength when cast in permanent molds is 28,000 lb. per sq. in., while the impact value is 0.58 ft.-lb. and the elongation about 0.5 per cent. The weight is 0.107 lb. per cu. in. Pistons cast in permanent molds are superior to those cast in sand. When cast in sand the tensile strength for this alloy is less than 27,500 lb. per sq. in.

It was necessary for us to develop also an alloy that could withstand a great amount of pressure. The alloy developed to meet this requirement has a tensile strength of 19,000 lb. per sq. in. and weighs 0.107 lb. per cu. in. It can be used for water-jackets and similar parts. Where it is necessary to use an alloy in a place where both pressure and temperature must be withstood, it is necessary to make a special alloy which embodies the properties of the two already mentioned. Cylinder-heads come under this classification. This information is given in the accompanying table.

In designing some particular part to fit the requirements of aluminum you, as engineers, can give the greatest assistance. Do not design a part and then select the material. If an aluminum alloy, on account of lightness or high heat conductivity, would particularly adapt itself to a part, consult someone who knows about such design. The history of the aluminum piston is rich in evidence proving the correctness of this advice. The aluminum piston is here to stay but we know that all experience with it was not pleasant. About 75 per cent of the trouble was due to the tenacity with which engineers clung to the design used for cast-iron pistons. We have overcome this and today we design aluminum pistons. The experimental work necessary to establish a satisfactory design for a piston was great, but the effort to sell it to engineers was even greater. Formulas for the design of pistons, for clearance, etc., have all been worked out and are available.

Alloy	Tensile Strength of Sand Castings, lb. per sq. in.	Impact Values, ft.-lb.	Elongation in 2 In., per cent	Weight per Cu. In., lb.	Use
Lynite 112	20,000	0.76	1.5	0.103	Ordinary castings like oil-pans, etc.
Lynite 145	27,500	1.96	4.5	0.106	Castings where greater strength is required, rear-axle housings, wheels, etc.
Lynite 122	28,000*	0.58	0.5	0.107	Castings used at high temperatures, like pistons.
Lynite 109	19,000	....	....	0.107	Pressure castings, like water-jackets, etc.

*Cast in permanent molds.

New Uses for Aluminum Alloys

The physical properties of the alloys in the table given have made possible the use of aluminum for parts not before constructed of aluminum alloys. Axle housings have been cast from one of these alloys and excellent results obtained. Fig. 6 shows a 3-ton truck rear-axle housing being tested. A housing of similar design but made from cast steel was also tested and it is interesting to compare the results. The aluminum housing weighed 90 lb., while the steel casting weighed 175 lb. Under a pressure of 6 tons the latter had a permanent set of ½ in., while the aluminum one showed none. Tests on the steel housing were not carried beyond this point. At 7 tons the aluminum housing had a permanent set of 3/64 in. and failure occurred at 9½ tons.

This same material has been used for truck wheels also. Several trucks equipped with aluminum disk wheels were tested at the Rock Island Arsenal. The test consisted in mounting the truck on drums which were connected to brakes for absorbing the load when the truck was running. Cleats were placed every 90 deg. on the drum. The truck was operated at a speed of 15 m.p.h., which meant that the tires were struck about 260 times per min. by the cleats on the drums. The impact was sufficient to raise the truck 1½ in. from the drum and also to result in breaking a number of parts on the truck by vibration. The test was equivalent to 500 miles and the wheels were all in good condition when it was completed. Each of the aluminum wheels used in this test weighed 82 lb., while the original steel wheels weighed 248 lb. each, making a total saving of weight of 664 lb.

The use of aluminum alloys in motor cars seems to divide itself into two sections

(1) Those parts made of aluminum at the present time
(2) Parts which will be made of aluminum in the future

To the first class belong such parts as pistons, crank-cases, cylinder-blocks, oil-pans, inlet manifolds, bodies, etc. It would be folly to try to prophesy to what extent aluminum will be used eventually in motor-car construction without limiting the prophecy to a period not greater than one year. At this time it is safe to expect such parts as wheels, rear-axle housings and the like will be aluminized. Many developments along different lines are in progress.

The Discussion

QUESTION:—Have you had any experience with Duralumin? The advertisements give physical properties exceeding any you have mentioned.

MR. JEHLE:—Duralumin is a rolled product. It is not a casting alloy. The alloys I have mentioned were all casting alloys. The tensile strength generally given for Duralumin is about 60,000 lb. per sq. in. We are confining our present activities to making castings and studying casting alloys.

E. W. WEAVER:—I have been told by people using aluminum cylinder-blocks that it was necessary to give them a Bakelite coating to make them hold water. Is that practice general?

MR. JEHLE:—We treat some castings to protect them against leaks. Sometimes the coating given them performs the additional purpose of protecting the casting against corrosion. The difficulty with leaks is greater in experimental castings than with castings made in regular production. If the first casting is porous it can very often be remedied by providing proper pattern equipment.

QUESTION:—How does the wear of an aluminum piston compare with that of a cast-iron piston?

MR. JEHLE:—The wear is about the same if both are operating in good cylinders and under good conditions. Wear depends upon the nature of the surfaces and the lubrication. If the conditions are equal there is no difference in wear.

QUESTION:—What is the least thickness you would recommend for water-jackets and water piping, to prevent leakage?

MR. JEHLE:—That depends largely upon the design. A 3/16-in. section can be cast, but one much thinner is not practicable. If such a section is cast against one of ½-in. thickness, this may cause trouble. The question of thinness of section is not only in regard to the thinnest that can be cast, but also depends upon how equal all the sections are. If all are made thin it is easier to get a good casting than if some sections are thin and others very heavy. A head with complicated water passages cannot be cast as thin as a flat plate.

QUESTION:—What work has been done with aluminum in place of cast-iron cylinder-heads, and what compression pressure can be used?

MR. JEHLE:—I have no test results or figures showing exactly how much the compression can be increased by the use of aluminum heads and pistons. It is, however, a fairly well-established fact that preignition does not result from the heat of compression alone; if it did, the compression in all engines would be the same. Accordingly, preignition must be caused by some local hot-spot. If that spot is on the piston or the cylinder head, this

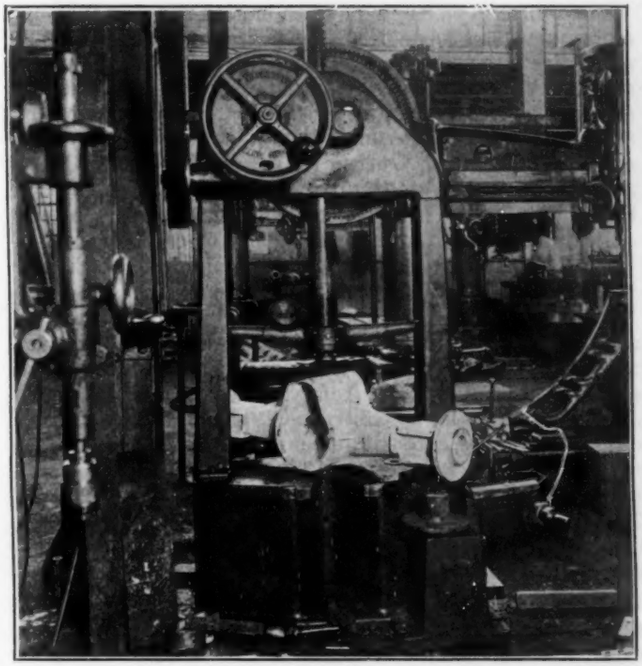


FIG. 6

can be remedied by using a material such as aluminum which is a better heat conductor.

QUESTION:—Is the bearing for the pin in the piston?

MR. JEHLE:—We make pistons both ways. We must make them as our customers want them, but we recommend that a floating pin be used, free in both the rod and the piston. By a floating pin I do not mean a loose one, but one which can be lightly tapped into place. If the pin has much clearance when cold, it will have more clearance when hot. Our experience has been that a floating pin in both members is superior to one held in either member. I would rather hold the pin in the rod than in the piston.

QUESTION:—Referring to wrist-pin fastenings, do you put a ring around the wall?

MR. JEHLE:—There are various methods of fastening. I prefer the small spring-ring in the end of the wrist-pin hole, if care is taken to sink it to more than one-half its depth into the aluminum. If this is not done there may be a wedging action that breaks the aluminum.

QUESTION:—Is aluminum ever heat-treated?

MR. JEHLE:—I understand that you refer to heat-treatment for strength. We do heat-treat some castings, such as pistons. We can regulate the hardness somewhat. Sometimes a piston may increase in size while it is in the engine, but we can do this ahead of time by heat-treating. However, I believe the strength is not increased.

QUESTION:—When aluminum is used in cylinders, is it necessary to season as in the case of iron cylinders?

MR. JEHLE:—Yes, it is a good thing. It would be well, I feel, if all the users of aluminum would do just the same with it as with cast iron, but it is hard to get them to believe that. Referring to the question of growth, this can be brought about artificially by a higher or a lower temperature, if the casting ages long enough and casting strains are thus relieved.

QUESTION:—I understand that in 1917 some Californian aeronautical firms were building four and six-cylinder experimental engines and that they experimented with aluminum valve seats. How did they stand up?

MR. JEHLE:—We now have an engine running that has aluminum valve seats, but thus far, for commercial purposes, we have been contented with cast-iron or bronze seats. A bronze seat is satisfactory, either cast or screwed in. For the inlet valve I think the aluminum seat would be satisfactory; but for the exhaust-valve I am not so certain. We ran an engine for several hours and it apparently stood up well. We prefer to cast in the bronze seats. The coefficient of expansion of bronze is nearer that of aluminum than that of cast iron.

QUESTION:—Can the toughness of aluminum, when it is to be used in place of malleable iron, be increased?

MR. JEHLE:—Aluminum alloys can in my opinion be used in every place where malleable iron can be, in regard to both strength and elongation. The strength and elongation of malleable iron vary over a wide range. Just how these can be controlled I do not know. I think our alloy having a tensile strength of 27,500 lb. per sq. in. can be used in every place where malleable iron is used. With a tensile strength for malleable iron of over 30,000 lb. per sq. in. and that for aluminum over 27,500 lb. per sq. in., we could still make a part of aluminum, having half the weight, by making the section thicker.

QUESTION:—Is it now possible to design an aluminum piston? How is this done? What has been the past experience?

MR. JEHLE:—The aluminum piston question is complex. We first made the pistons too light, with heads about 3/32 in. thick and the walls of about this same thickness. We took too much advantage of lightness. We found that we had to use more metal. Then we were a long time finding out the proper clearance. We tried to run pistons with too small a clearance. One of the best examples of aluminum pistons, I believe, is found in the Liberty engine. This piston was not as light as we could make it; it weighed about 3 lb. and had a head about 3/8 in. thick. We now have several formulas, based upon the heat that must be conducted from the pistons into the water-jacket, for calculating head thickness, etc. We get a certain amount of heat in the piston-head which depends upon the exposed area and we must provide enough metal to dissipate it. The exact duplicate in cast iron would weigh two and one-half times more than the Liberty piston. Since cast iron is a poorer conductor of heat by one-third than aluminum, three times as much metal must be added to give it the same conductivity. This would produce pistons weighing seven times as much, or 21 lb. We are now basing piston calculations on Liberty engine performance, making an allowance for the fact that the horsepower output per square inch is less in automobile than in aviation engines. The next important thing to be settled is how much clearance to give pistons. This depends largely upon the individual engine, but we have been successful in devising a formula that gives a good starting point for tests. We find that if we allow 0.0006 times the diameter of the piston squared, we get about the correct clearance. That may be a trifle too much or we may find that a trifle more is necessary. Then comes the question of ring fits; they should of course be just as close as possible in the grooves. If a ring is loose when cold, it will be looser when hot.

QUESTION:—It is said that the Franklin company is using aluminum pistons very successfully.

MR. JEHLE:—The Franklin company is using aluminum pistons. Of course, the clearance formula I gave must be modified in an air-cooled cylinder. There is a different condition in air-cooled from that in water-cooled engines.

QUESTION:—If aluminum can stand compression, why use a cast-iron sleeve in an aluminum block?

MR. JEHLE:—That is a question of bearing surfaces only. Cast iron seems to be, as far as we know, the only metal that works well as a bearing when both parts are made of it. We may later be able to get an aluminum alloy that will run successfully on another aluminum alloy, but to date we have not found it.

QUESTION:—Is the coefficient of heat expansion the same in all aluminum alloys?

MR. JEHLE:—It is very nearly the same. The expansion of aluminum alloys is very close to that of the expansion of pure aluminum, so far as we know now. While we may gain a small percentage on one alloy it really does not amount to much. Even if we found an alloy that would expand 10 per cent less than some other, 10 per cent of say 0.007-in. clearance is not within manufacturing limits. If we could find an alloy that would cut the expansion one-half, it would be worth while.

A. W. HUBBLE:—What are the objections to the use of aluminum pistons? We have done much experimenting in England with the aluminum piston. We have had some trouble, the chief one being piston slap.

MR. JEHLE:—The fact is that the definition of piston slap is quite elastic. I have known it to cover everything from a slight tapping of the piston to the noises in the rear axle. Nevertheless there is such a thing, and when pistons are larger than 4 in., it becomes more serious. Piston slap is one thing we must overcome. Clearance, of course, is what brings it about. We find, however, that in pistons of not over 3¾ in. in diameter, it is not serious if the wrist-pin location is in the center of the bearing surface and the clearance is kept close. I do not mean the clearance given on blueprints, but that actually found in the engine. Strange to say, therein lies a difference. I have taken pistons out of new engines and so have come into possession of new pistons that actually measured more at the top end than at the bottom of the skirt. Tapering pistons is good practice and to a certain extent overcomes slap, but we have to taper them in the other direction. Now we find there are two ways of tapering pistons; one, a straight taper from the skirt to the top; the other, to make the piston straight part of the way and then taper it, which I believe is the better method. This has to be resorted to in large pistons. The majority of the cars use 3¾-in. pistons and we do not have much trouble with pistons of that size.

QUESTION:—Why have the pin tight in the piston?

MR. JEHLE:—The wrist-pin hole gets larger and the clearance between the pin and its bearing will be larger when the piston is hot than when it is cold, but the methods for fastening a pin in a piston are difficult. From tests, I believe the best way to put in a pin is to let it float in both members. Put it in tight in the piston; make it a tapping fit so it is tight when the engine is cold. Recently I put in a set of pistons in which the pin was held by pushing a cotter-pin through a hole in the pin and wrist-pin boss. The cast-iron piston was held that way and they did not want to change the design. We put the pistons in and when we took them out five of the six cotter-pins had been broken. In cast iron that fastening might have been successful, because the pin would have expanded as much as the piston, but with aluminum the piston expanded away from the pin which became loose and the cotter-pins sheared off.

The Automotive Situation in the Allied and Associated Countries

AT a meeting of the Detroit Section, C. C. Hanch, general manager of the Maxwell-Chalmers Corporation, and H. E. Coffin, vice-president and consulting engineer of the Hudson Motor Car Co., spoke on the condition of the automotive industry in the allied and associated countries. Mr. Hanch went abroad after the signing of the armistice in November, 1918, to study conditions and make a report on them.

ADDRESS OF C. C. HANCH

I SHALL describe a rapid trip through England, France and Italy and visits to some of the automobile plants, touching upon some of the important affairs connected with the automobile industry.

I landed in Liverpool last February. The people were then just beginning to come out of the war cyclone cellar. They did not know the war was over until then. One could form no conclusions or have an intelligent opinion on conditions over there prior to that time. The first thing that struck me in Liverpool was that an enormous shipping business was being carried on with practically no motor trucks. On the contrary, in spite of the length of the war, I saw great quantities of magnificent teams of horses in the large industrial cities of England. In going from Liverpool to London, I did not see a single freight car that would hold more than one full-grown automobile or truck. This gives an idea of our comparative situation from a shipping standpoint.

In London, at that time, there were perhaps 10 per cent enough taxicabs to supply the population, and the drivers were not very anxious to work. If it was lunchtime it was hard to get any service. On the contrary, in daytime, the bus system of London gives splendid service. I would like to see the equivalent of the London buses in more streets of our own cities. They would be of great assistance to our present overworked transportation systems. One impression that I received in London was that in one drive it required an hour and three-quarters to get through traffic in an automobile, a distance of probably two blocks. That situation occurs at certain hours daily, due to the almost exclusive use of horses, big drays and very light loads, at low speed.

In Paris I was not dependent upon taxicabs, but the same situation exists there as in London. The taxicab drivers were indifferent and reckless. There were not over 25 per cent enough taxicabs to supply the city, and they were largely old two-cylinder Renault cars. The drivers were getting $8 per day in gold at the time, being paid upon the basis of 40 per cent of the receipts and having to buy their own gasoline. This was in March. I noticed also in Paris the total absence of local traffic rules, although the American military police had a semblance of rules for American military automobiles. People ordinarily drive as they please. It is a habit of Paris taxicab drivers to go about 25 m. p. h. and turn sharp in the street without giving a warning signal. Consequently, wrecks in the streets of Paris were frequent.

My purpose in going to Paris was to attend the Conference of Inter-Allied Automobile Industries. There were delegates from England, France, Belgium, Italy and the United States. There has been an international organization over there for a number of years of automobile industries, formerly including those of Germany and of Austria. After the war delegates from the United States were invited to take the place of the former members from Germany and Austria.

The first day no business was done. The second day they began work, but had only three or four topics. One was the international relation of automobile shows. We found that the dates of the Paris, London, New York and Chicago shows did not conflict; it was agreed to establish those dates permanently and that exhibitors should be admitted to the shows upon reciprocal terms. Whatever terms we imposed upon the exhibitors from France and England, they will impose upon us in Paris and London. They desired to have their show rules adopted throughout the world, but I think they are not applicable to conditions in America. Their rules provide that any manufacturer who has exhibited for three consecutive times at a show, regardless of how many cars he made, is entitled to exhibition space of equal prominence with that of the largest manufacturer. The conference decided to establish a permanent bureau of the organized automobile industries, which simply takes the place of the former organization, leaving out Germany and Austria.

Standardization

The subject of standardization was not on the program and I asked them to put it down for discussion. They accepted the suggestion and I have since learned that they have earnestly made efforts along that line, taking up a number of things which are fairly well standardized in America, such as the mounting of electrical units, battery sizes and locations, electrical terminals, tires and rims. I felt that we in America had everything to gain from such standardization, and that it would be a good thing for them. It was a new idea to them. In the past all of the European manufacturers thought that every part of a car must be unique and different from that of every car made by any other manufacturer. They thought this was necessary to hold their service trade.

I brought up also the subject, which has since been followed up systematically, of the reduction of annual taxes for the use of automobiles. Taxes are very high. They decided to inaugurate publicity campaigns in England, Italy and France, simultaneously; to reduce the taxes on the use of automobiles and on gasoline. I am advised that they have already accomplished some good results, particularly in England.

Import Duties

The last and most delicate subject handled by the conference was that of embargoes and customs duties. It was at this stage that I became acquainted with the real mental business attitude of the European people, the Latin people in particular. It was the thought of many of those men that America had gone into the war for absolutely selfish purposes. They seemed to have no

conception that we had gone into the war for the unselfish reasons which we all feel in our own hearts were our true motives. They felt that we had made great sums of money out of the war before we went into it, and had become immensely wealthy; that they had suffered hardships which we had not borne; and that therefore the equitable thing for the American people to do is to pro-rate the entire cost of the war from the beginning with all of them; cancel all of their debts to us, and cease entirely to compete with them, or to ship any automobiles over there. I could not accept this economic formula and became involved in some discussion over the subject before I left France. Finally, they proposed a resolution on the question of tariffs and embargoes, but upon my insistent objection they rested with simply stating their position.

The statement of their desires in regard to tariffs is that there should be reciprocity on a basis of 10 to 15 per cent ad valorem, provided the tariff charged by any country should not be less than that charged by the country of exportation; and that in no event should the tariff be less than the tariff charged by the country of exportation before the war. This, of course, was a joker aimed at the United States, inasmuch as we had had a higher tariff. Regardless of any tariff we might make in this country, no matter how low, they proposed to interchange between themselves on a 10 to 15 per cent ad valorem basis, and charge the United States not less than 30 to 45 per cent. They have consistently followed that idea, because in France they are charging us today 70 per cent ad valorem, c.i.f., and in Great Britain they are charging us 33 1/3 per cent ad valorem, c.i.f. They have not yet made duties between themselves on a basis which discriminates against the United States, but unless there is a firm policy in the United States on the part of Congress they will discriminate against us. It is surprising to know that France is the only nation that has for years enacted discriminatory tariff legislation against the United States.

Automobile Factories and Methods

I left Paris on March 13, and went to Lyons. It had a population of 500,000 before the war, and when the great French industrial city of Lille was taken by the Germans, every one who could went to Lyons. The population was increased from 500,000 to 1,000,000 almost over-night. I do not know what our people who complain of congestion in cities would think if they saw the conditions in Lyons. There is not a sewer in the city. It is one of the livest places in France. The fair which is held there annually to take the place of the former fair in Leipsic, Germany, is a very great demonstration. They have 15 miles of booths for exhibitions, and a very creditable automobile show.

In Lyons I visited the Berliet automobile factory, the second largest in France and very well managed. There are two plants. The old automobile plant is in the heart of the city. The new plant in the outskirts is laid out properly and capable of developing into a modern plant if they can induce labor to work on modern lines. There was no sign of being able to arrive at that result at the time I left.

From Lyons I crossed the Alps into Italy, first visiting the industrial city of Turin, which is the Detroit of Italy. The Fiat factory, the largest in Italy, is located there. My first impression after arriving in Italy was that its entire army was on a leave of absence. I never saw so many soldiers in uniform with no place to go. They seemed to be very happy, but they were not doing anything. In Turin I was brought face to face with the condition we hear so much about, of people not wishing to go to work after the war.

The Fiat company had 40,000 employes during the war. When I was there they had 22,000, and were not doing much. They had been working effectively during the war, but as soon as the war was over the men demanded an eight-hour day and various other things. The management gave them the eight-hour day by permitting them to go to work at eight o'clock in the morning and not allowing them to stop for anything until the eight hours were ended. That was an innovation to try to discredit the eight-hour day, but it simply made bad matters worse.

The Fiat factory is the largest automobile plant in Europe. Only one large section of the plant is adapted to economical mass production of automobiles. It will take them two years to complete that section. The remainder of the plant is scattered in seven different separated shops. They have reasonably good foundry facilities, a good forge shop and good machine tools, many of American make, but no sheet-metal equipment whatever. I saw nothing better than a wooden form and wooden mallet for handling sheet metal in any automobile plant in Italy, France or England. I saw nothing in the way of progressive arrangement for machining, although there were a few attempts at progressive assembly. In a few places they had trucks or tanks on a progressive assembling track, but notwithstanding the attempt, they did not have progressive operations. For instance, where they had tried a progressive assembling track, it was not working progressively. It stopped and they finished the job where it stood. It will be many years before European labor will adapt itself to the progressive method in vogue in America, which has resulted in producing the American automobile at its present price and in the present quantities.

At Turin I had my first opportunity to examine critically the types of modern automobile they are producing. Practically every post-war model of automobile in Europe is a 10 or 12-hp. machine, with engine of very small bore and fairly long stroke. They rely absolutely on four gearshifts and a low gear ratio; they change from one gear to another and seem to expect to change gears. That type of car will give reasonably satisfactory results on the good roads they have, and no doubt has advantages where the price of fuel is very high, but would be wholly unacceptable anywhere in America or in any other place in the world where there is heavy going and high ground clearance is required.

The principal plant in Milan is that of the Isotta-Fraschini company. It is a beautiful factory but like all the European plants they have lathes in one corner and drills about half a mile away. They turn a piece, carry it a long distance and drill it and perhaps carry it back for another lathe operation. Everything is done by hand, by main strength, and there are no facilities for handling the work progressively.

After returning to Paris I visited a number of industrial plants, among others the Renault automobile plant, the largest in France. I know of no plant in America with which to compare it. It covers much ground. It has no progressive machining or any indication of it; in one wing they attempted progressive assembling of tanks. Their airplane plant is separated from the main factory, and would make a very good modern automobile assembly plant. They were converting it into a body plant at the time I left.

Europe as an Automobile Market

The principal French motor-car factories claim a capacity of 149,000 cars a year. My estimate is that during the twelve months ending July 1, 1920, they will have produced 50,000 automobiles as a maximum. In England, all of the principal plants have a claimed capacity of 63,000 cars a year. I think they can turn out within the same period 40,000 automobiles. The truck manufacturers of England, after four years of continued effort, spurred on by the needs of the war, produced only 13,000 motor trucks in 1918. The entire motor-transport equipment made in England for English use and including purchases in America, amounted to 82,000 vehicles at the end of the war. France commandeered 40,000 automobiles in civilian use at the beginning of the war, and notwithstanding their production and their purchases they had only 50,000 vehicles at the end of the war. The United States in approximately twelve months of effort put 70,000 motor vehicles in use overseas, 66,000 were of our own make and 4000 were purchased abroad.

The population of England, Belgium, France and Italy is 127,000,000; they have 350,000 automobiles, one to every 363 people. The United States has 110,000,000 people; on Jan. 1, 1919, we had 6,000,000 automobiles, one to every 18 persons. England alone has 45,000,000 people and 200,000 automobiles; one to every 225 persons. France has 40,000,000 people and 100,000 automobiles; one to every 400 people. Italy and Belgium combined have 42,000,000 people and 50,000 automobiles; one to every 840 people. This is in spite of the fact that there are good roads in all these countries.

They have universally treated the automobile as a luxury and trained the public to regard it so. The small low-powered automobile they are making as their post-war design is just as expensive in proportion as was the high-powered car they made before the war. In my opinion European manufacturers will never fully develop their own potential market. It will rest with American manufacturers either to make cars over there or export from this country. On the other hand, if our Government reduces the duty too much, many people in this country will buy foreign cars. There is no question that we would have competition if the doors were wide open.

Labor Conditions

The labor situation is most important today, not only in the United States but in every country. The productive manhood of Europe was practically taken out of industry and put into the war. There are just two fundamental habits of mankind and they are the habit of idleness and the habit of work. The work habit is the best of all habits and the idleness habit is the most vicious. All other habits are collateral to one of the two named. The effect of four and a half years of war was to inculcate the habit of idleness, notwithstanding that the men were fighting and risking their lives part of the time. They must overcome the habit of idleness before Europe can emerge from labor trouble.

ADDRESS OF H. E. COFFIN

I HEARD the Earl of Reading make a speech in London recently. His subject was the financial foundations of the British Empire. He concluded that the financial foundations of the British Empire were perfectly secure if British labor would return to work and start quantity production. I think that lack of quantity production is the greatest fundamental difficulty in the world today. There is no use in increasing wages and immediately raising the prices to the American public to take care of this increase in wages. That is an endless procedure. So long as American labor holds off quantity production while we have strikes continually and continue to deal in a half-hearted way with the situation, there will be a continual increase in the cost of living. There is no other solution, no other end to the cycle, except a quantity production which will automatically decrease the prices of commodities. We all realize that if there were an over-production of motor-car materials in the course of the next year, there would be a reduction in the price of automobiles. There has never been a time when that principle did not hold true. It is applicable to any other line of commodity supply.

The situation in Europe from a production standpoint is perhaps only what might have been expected. When the European nations entered the war they had no idea of the magnitude of the undertaking. Germany had no idea of it; neither had France or England. Germany estimated that she had stored up, during some years of preparation, enough ammunition to carry the war through. She did not expect the war to continue for more than a brief period of months. As soon as she began to realize the futility of this dream and the munitions began to disappear, she saw, for the first time, the necessity for the quantity production of war materials. There was a time when German munitions were practically exhausted. The Allies experienced the same difficulty a little later. There soon came a necessity for quantity production of all materials that pertain to war. In all the major countries of Europe quantity production was achieved, but under war conditions and therefore under a controlled labor market. These were conditions in which economy was one of the last considerations; the amount of money spent in plant extensions or in the production costs of the commodities was not a first consideration; and where there was no limit on tool equipment or in the use of any other essentials for obtaining the desired quantity production. Previous to the signing of the armistice and immediately following it, European manufacturers boasted that, since they had learned to produce in quantity in accordance with American methods, they would be a greater factor in the world's trade and more active competitors of the United States in the very things in which this country had always been preeminent.

So-Called European Quantity Production

In November, December and January, representations were made by the British to their trade connections throughout the world, and to a certain extent also by French manufacturers, to the effect that since they had learned the American secret of quantity motor-car production, and had the added advantage of the excellence of European labor, motor cars would be supplied to the export markets at prices far below anything ever yet achieved in European countries. They represented also that the quantities would equal those mentioned in the reports of great American quantity production. As a result, in countries like Australia, dealers were saying to our representatives that they would now deal with the home country, that quantity production had been achieved there and that the era of the cheap motor car of European manufacture had come. Months have passed and the Australian representatives have had notices from their home offices that there has been an increase in the price of motor cars and directing that orders be reinstated upon the basis of the new price. Meanwhile there

have been no deliveries. There have been several such notices, the price has returned to about the old pre-war figure and quantity production has not yet been achieved. As a result, foreign representatives are eager to do business again with the American manufacturer. The European manufacturer must now consider questions of financial outlay and economical production; he must deal with a difficult labor factor. Europe's and American's labor problems are intermingled with the subject of quantity production.

The hardship of cancelled contracts which American manufacturers complained of following the armistice, has proved a blessing in disguise. In Europe there was a great fear about throwing labor out of employment and, to guard against this, government war contracts were continued for months after the armistice. In France some manufacturers were producing munitions at a very much higher rate in January and February of 1919, than at any time during the war. The different governments were continuing to pay for all material and the manufacturers were trying to produce as much as possible before the time limit expired. This course of action did keep labor employed, but also caused a very bad reaction. It kept the manufacturing brains and productive power of these countries engaged upon work that was in no sense commercial. It involved great waste of material and effort.

Delay in the signing of the Peace Treaty prevented industrial recovery. Manufacturers generally were uncertain as to what the commercial conditions of peace would be, and hesitated to launch new activities until questions of import duty, of finance, and raw material supply could be clearly defined. In short, Europe remained to a great extent under military control. As war contracts finally terminated and plants began to shut down there was a tremendous amount of dissatisfaction and unemployment. In England an allowance of some 28 shillings per week was paid by the Government to all workers who were unemployed. There is no more fertile field for trouble than in a group of unemployed, especially if it is their desire to sow the seeds of industrial unrest and dissatisfaction. I should say that the delay in the execution of the Peace Treaty, perhaps more than any other one thing, tended to bring about the present highly unsatisfactory labor situation in the Allied countries.

American Colonial Export

One interesting development in connection with our trade, as related to the export trade of Europe, is that during the war colonial manufacturers and dealers generally have been forced into contact with American manufacturers and their methods. We formerly heard a great deal to the effect that American manufacturers were not taking care of the colonials as well as were the European firms. There was a constant demand for different types of chassis and body for a long wheelbase, and different kinds of equipment. In fact, the American manufacturer did little that was right. There has been a reversal of form in this connection. The colonial buyers have learned that American products are mainly satisfactory and that American business methods appeal to them after they learn to know American manufacturers. There is a great change of sentiment among them in this respect. I believe that European manufacturers must bring their methods more nearly in keeping with American procedure. But American manufacturers must be careful to cultivate the friendly feeling which has thus been developed, and they must properly and tactfully handle the business which has been built up. Above all else, they must take care of repairs. Ordinary repairs can be made promptly on American cars and this feature is making a very strong appeal indeed to all purchasers who are located in foreign countries.

Aerial Development

The British policy is one of insuring coordination between the three arms of defense, which they consider co-equal, the Navy, the Army and the Air Force. They have a separate ministry of the air, dealing with the commercial as well as the military aspects of aerial development. It is their theory that military preparedness in the air can be assured only through the active encouragement of the development of commercial aviation. Lines are being organized from London to India and Cape Town, and England stands prepared today to join with the American Government in the establishing of a transatlantic mail dispatch and passenger service. The transatlantic flight of the R-34 was simply an experiment to gain experience. The R-34 was conceded to be out-of-date in design. They are engaged in the construction of very much larger and better machines. They have developed an interesting system for the transmission of correspondence. It is a system of photographic reduction of business correspondence to postage-stamp size, on one side of the Atlantic, and the reproduction of that correspondence to its original size on the other side. Thus, letters of standard business size will be reduced to tape and carried in miniature overseas. In this way practically all of the transatlantic first-class business mail can be carried by air in an astonishingly small tonnage space.

From a military standpoint, the system planned by England is based upon the theory that the young officers of the war and navy departments of today will constitute the "high commands" of the military and naval forces not many years hence. It is proposed therefore to give the young officers of both services a thorough training in the theory and practice of aerial strategy, so that when they do succeed to high command they will carry with them an accurate knowledge of the possibilities and uses of aircraft. The development of the Air Force had come into its own just before the armistice, and for the first time fleets of 200 and 300 machines were being used in mass formation, for the raiding of ground troops and for the execution of strategic operations far behind the German lines.

The British policy contemplates the establishment of an Air College similar to our West Point and Annapolis Academies. Their plan calls for the "circulation" of officers of the Army and Navy Departments in considerable numbers through this educational institution, and through some three years of service in the Air Department. They will thus go back later to their own services with a thorough knowledge of aeronautics and a sympathetic appreciation which will insure coordination of the several services. We have had experience enough here since the armistice to show us that there will be no possibility of a definite aerial policy in this country until we have, like the British, a separate department or division of the government, living and dealing constantly with the problems of the air-service development, civil, military and naval. Aeronautics cannot be handled as a side issue as at present. For example, the idea of assigning a cavalry officer, under the present system, to a more or less temporary command in a department as technical and intricate as that of the air, is utterly impractical. The mission of which I had the

honor to be a member placed itself squarely on record in this matter, after investigating conditions in Italy, France and England. The American Aviation Mission recommended that the air activities of the United States, civilian, naval and military, be concentrated within the direction of a single governmental agency, created for the purpose, co-equal in importance and in representation with the Departments of War, Navy and Commerce, and that the agency thus created should be charged with full responsibility for placing and maintaining our country in the front rank among nations in the development and utilization of aircraft for the national security and in the advancement of the civil aerial transportation and communication arts.

REPORTS OF NATIONAL ADVISORY COMMITTEE

THE National Advisory Committee for Aeronautics, Washington, has recently issued four interesting reports. These are No. 28, which gives an introduction to the study of the laws of air resistance of airfoils; No. 49, dealing with the metering characteristics of carbureters; No. 50, on the calculation of low-pressure indicator diagrams; and No. 75, relating to the aerodynamic properties of certain airfoils suitable for internal bracing.

Synopses of these reports are given below.

Report No. 28

This report which is an introduction to the study of the laws of air resistance of airfoils has been written to give a general survey of the present state of knowledge on this subject. After summarizing the history and the bases of the present-day treatment of the phenomena of fluid resistance in the introduction, a critical discussion of the fundamental concepts used to describe the fluid resistance properties of airfoils is given. The concepts of the angle of attack, center of pressure, airfoil area, metacenter, metacentric curve, zero lift line and resultant air resistance are examined. The question of the apparent flow deflection produced by an airfoil is next discussed, being preceded by a preliminary investigation of the general properties of vortices. The tip vortices are next investigated and a general account of the intensity and direction of these is given. A study of edge vortices and a general account of their properties including the main qualitative relations that hold for them follows. The possibility of the formation behind an airfoil of two waves, designated as the primary and secondary waves, is touched upon and the numerical values of their magnitude given.

Report No. 49

Scientific research conducted for the Committee is covered by this report which has been prepared by P. S. Tice and Dr. H. C. Dickinson of the Bureau of Standards. It is divided into six parts. The first describes the carbureter testing equipment constructed by the Bureau of Standards, which permits the testing of carbureters and their elements at widely varying air pressures and temperatures for steady and controlled pulsating flow. An included orifice meter is employed to determine the air quantities and the fuel quantities are determined by weight.

The second section describes the results of experiments to determine the effects of varying the diameter, length and form of entrance of the metering passages, as well as of fluidity change with temperature, the conclusion being expressed that the control of mixture ratios can be obtained by the simple selection of the ratio of diameter to length for the fuel metering passage. In the next section the results of experimental determination of the coefficient of discharge for various types of carbureter air metering passages are touched upon. From the results of these investigations it has been found that the discharge coefficient increases with the throat velocity up to about 145 ft. per sec. and remains practically constant thereafter, this coefficient not being materially affected by variations in passage form, air density or amount of fuel admitted to the air-stream.

The fourth part gives the results of experimental determinations of the effect of pulsating air-flow upon the metering characteristics of two carbureters embodying widely different metering methods. It is pointed out that pulsations of the usual rates and amplitudes exert a practically negligible effect upon carbureter capacity, but that the metering is sufficiently affected to necessitate the consideration of pulsation characteristics if mixture ratios are to be controlled accurately. The fifth part is a discussion of the theoretical and experimental mixture proportioning characteristics of carbureters as applied to aircraft service and the mixture ratios for the best engine performance. The altitude and throttle compensation characteristics which have been experimentally determined for five carbureters are studied and a new type is shown that possesses nearly complete altimetric compensation. The mixture ratio which produces the maximum power is practically constant at 15 to 1 for gasoline at all air densities, but the ratio for maximum economy decreases with the air density. Ordinary variations in structure and fuel control, while very materially affecting throttle compensation, exert an appreciable effect on the altimetric compensation. The last section discusses means for securing direct altimetric and throttle compensation, it being pointed out that several methods will be equally effective; that automatic regulation is more desirable than manual and that an automatic control can be made to provide complete compensation.

Report No. 50

A theoretical study of the pressure variations in an internal-combustion engine cylinder during the low-pressure portion of the cycle is contained in this report. It is assumed that the rate of flow of air and burnt gas through the inlet and exhaust valves respectively can be calculated from the manifold pressures, the cylinder pressure and the valve clear openings, by the ordinary formulas for steady flow through an orifice with the aid of determinable coefficients of efflux. Differential equations for the rate of change of the pressure in the cylinder during the exhaust and suction strokes are set up. A method for the graphical integration of these equations is indicated. Efflux coefficients taken from the experiments of Lewis and Nutting are used in the application of the theory to a typical engine, and a theoretical low-pressure indicator diagram is obtained.

Report No. 75

This report deals with the results of a series of tests conducted at the Massachusetts Institute of Technology wind tunnel, with a view to developing airfoil sections thick enough to permit of internal bracing and the use of cantilever wings without any external bracing of the airplane wing truss. The sections tested were based on the Durand 13, and were varied in section form, in thickness along the span and in chord along the span. Tapering both in thickness and in chord was found to be highly beneficial to efficiency, and some of the wings developed gave lift-draft ratios practically as high at angles corresponding to very high speeds of flight as the best of the wing sections for normal type, together with very much higher maximum lift coefficients. In particular, it was found that the substitution of a thick tapered wing for R. A. F. 6 on a 3600-lb. fighting biplane with a Liberty engine would increase the maximum speed by 18 m.p.h., due to the saving in parasite resistance by entire elimination of the interplane bracing.

Copies of all these reports can be obtained from the Committee upon request.

Adapting Truck and Tractor Engines to Motor-Boat Use

By Joseph Van Blerck[1] (*Member*)

Motor-Boat Meeting Paper *Illustrated with* Photographs

THE automobile engine, as used in passenger cars and a large percentage of trucks, is not adapted to use in motor boats, and is not built substantially enough, since the power output of the motor-boat engine, except when starting or landing, is always 100 per cent. In view of this and because tractor, truck and marine engines are of the same family, it would appear that if a truck and tractor engine were made with 100 per cent power output, we would then have a combination which would answer these three purposes. The marine engine must be capable of running under full load for an indefinite time at a 12 to 15-deg. incline. It was found that nothing satisfactory could be evolved from the old-time plan of building engines; we therefore awaited an opportunity whereby the marine engine could have the advantages of large production. These advantages are many; the difficulties encountered in the small shop of low production are obvious.

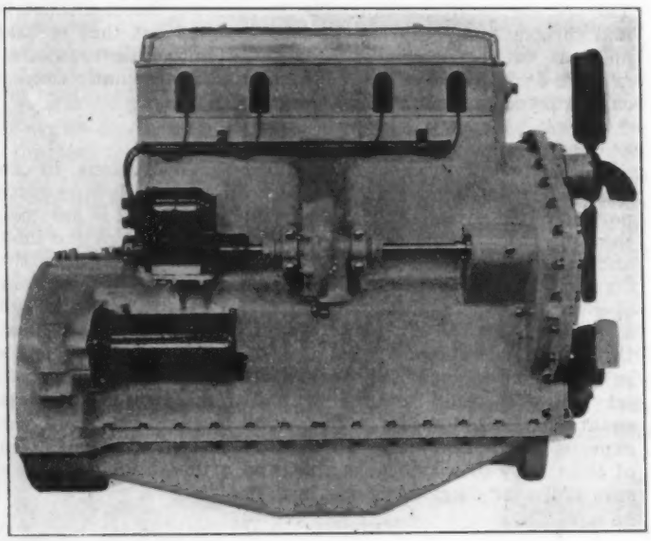


Fig. 1

Fig. 1 shows a tractor engine. It has a fan driven by a gear, a governor on the engine and an oil sump. The oil pump is in the center of the sump to provide adequate oiling at either an up-hill or down-hill angle. A reversing gear is attached to the engine. The fan and governor are separate units and can be attached or detached at will. The flywheel is in the rear of the engine, with the clutch located within the flywheel; the power is thus transmitted through the flywheel. This is the only proper way to transmit the power. Difficulties have always been encountered, and marine engines have been designed to suit boat builders and naval architects. The result has been that flywheels have been installed at the front part of the engine. Some marine engines have, however, been built with the flywheel in the rear, but this was only in the case of heavy-duty engines for large boats and it was claimed to be impossible to install such engines in small cruisers or runabouts.

I have made a slightly different oil sump. The flywheel is smaller and allows for dropping the engine closer to the keel. This is being done to avoid criticism and to get the engine into boats which are already built, but I am satisfied that there is no need of having this oil sump when designing a new boat. I hope to receive sufficient support from naval architects and motor-boat engineers, so that within a short time this oil sump will not be required and we shall be able to use the deep oil sump, thereby making the entire assembly standard. The reason for making the deep oil sump is that, on account of using the engine for cruisers, a heavy flywheel is desirable. However, we must eventually make two kinds of flywheels to answer these two purposes, as the runabout engine for high speeds does not require such a heavy flywheel. We use the same supporting arms that are used on the tractor engine, except that we have made two foundation plates for bringing them to the center of the shaft. This would be unnecessary except that it is easier for a boat builder to build the foundation on the center line of the shaft. Concerning the engine supports, if these are sufficient for the engine in a tractor or a truck, they will support the marine engine, which must withstand certain shocks but nothing like as severe as those of tractor and truck service.

Right and Left-Hand Engines

We have been building right and left-hand engines, which means that for a twin-screw boat both engines must run out-board. We have discovered from past experience that it is unnecessary to have both engines running out-board; in other words, both engines can run the same way and there will be no difference noticed. We are well on the way to attaining this point. Several boat builders are working on twin installations and planning to have both engines run the same way; in other words, they will use two standard engines. To make engines run in opposite directions we must change the rotation of the oil pump, magneto, water-pump, generator and starting pump; it also necessitates a different camshaft. Our oil and water-pumps are made so that they can be run either way at will; but it costs more to do this, as parts for these pumps must be kept on hand.

[1] Manager, motor division, Wellman-Seaver-Morgan Co., Akron, Ohio.

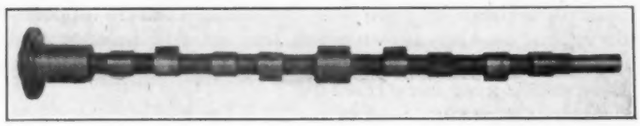


FIG. 2

Fig. 2 shows the camshaft. It is made in such a way that it can be used for a left-hand camshaft by cutting off the bearing and flange on one end and reducing the shaft to the same size as the opposite end; then making a separate bearing, coupling and key in this end. The necessity of asking camshaft manufacturers to make left-hand camshafts is thus obviated. Fig. 3 shows the tractor engine from the opposite side; the centrifugal pump can be seen. Fig. 4 shows the marine engine with the centrifugal pump taken off and a gear pump installed in its place. The centrifugal pump is unsatisfactory because of its inability to suck water. The gear pumps are made so that we can disassemble and reassemble them for left-hand pumps without any extra machine work.

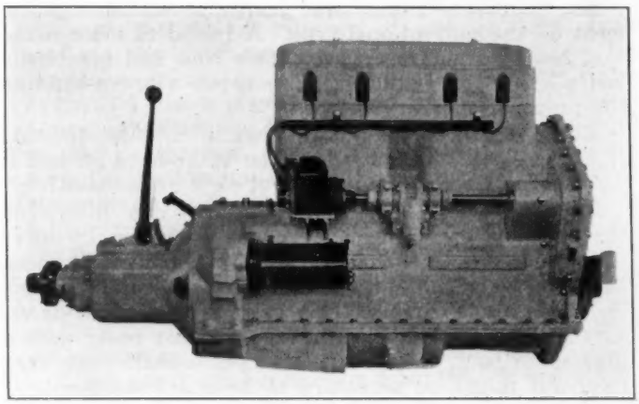


FIG. 3

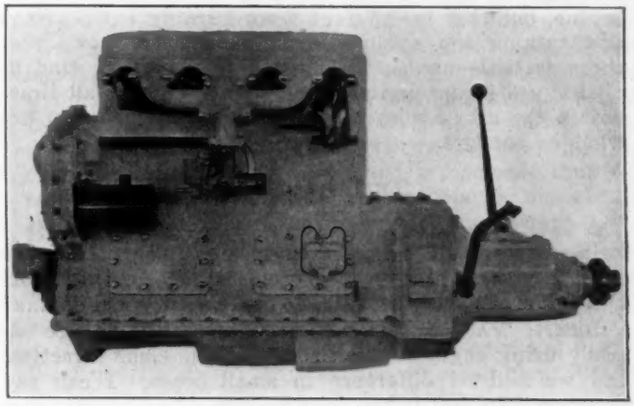


FIG. 4

We hope ultimately to convince naval architects and boat builders that it makes no difference in small boats which way the engines are running.

SLIDING REVERSE GEAR

The sliding reverse gear is another interesting feature. This is the first incorporation of such a gear in a marine engine in this country, except in a few cases where an automobile engine has been used in a motor boat and the automobile transmission has been used. This use has, however, never been successful, due to the fact that the reverse ratio is too low in the automobile transmission. Our reverse gear has an 82 per cent reverse and this can easily be made a 1 to 1 reverse. The reverse gear has been tried out under both normal and abnormal boating conditions and has given absolute satisfaction. I firmly believe that this is the only practical way known for reversing a propeller. The gears used in this reverse gear are now manufactured in shops where they make transmission gears and advantage can thus be taken of the experience of the transmission gear manufacturers, insuring the making of a first-class gear. The gears are made along the same lines as the transmission gears for cars and trucks, of nickel steel, case-hardened and ground. Fig. 5 shows the gears as they are assembled in the housing. I will outline a few of the things that can be done with this reversing gear. When the lever is in the neutral position, with the engine running, the propeller-shaft can be turned by hand in the opposite direction because it is entirely separate from the engine. Therefore, a perfect neutral is obtained. Considerably less power is thrown on the engine when reversing than when in the go-ahead position. In other words, when the engine is running in an idle position and is then thrown into the reverse, there is absolutely no danger of stalling the engine. When the boat is going at full speed, if the occasion arises to reverse at once the first thing is to throttle the engine. The engine will then act as a brake to retard the speed of the propeller-shaft, say down to about 300 to 400 r.p.m., which is the required speed for shifting the gears. Between the time of shifting from the forward into the reverse position, the propeller has no chance to pick up speed through the momentum of the boat. This gear can be shifted from the forward to the reverse position just as fast as it is possible to shift from first into second speed on an automobile.

In the case of the twin-screw boat, the propeller of the dead engine is free to revolve in the water; it therefore does not retard the speed of the boat because there is one short shaft revolving which runs on two ball bearings. This is a great advantage in an auxiliary yacht which depends upon having the propeller running freely in the water while under sail. It will be appreciated what the drawback has been in the past and to what extent this reversing gear will remedy the condition. In regard to connecting the clutch and gearshift in different places in the cruiser, this can be accomplished

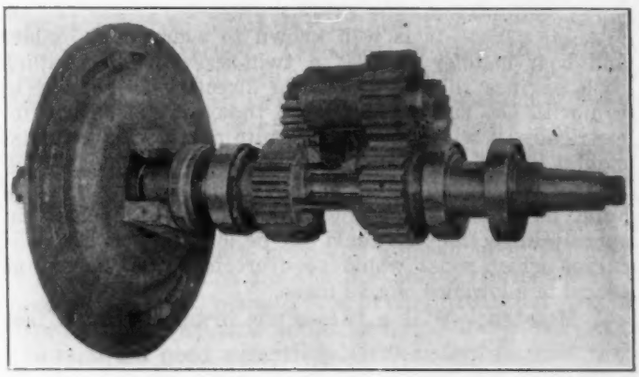


FIG. 5

much more easily than with any other kind of clutch because it works only one way. It can be worked with a cable and pulleys if necessary. Relative to the gear-shift lever, this does not require any strength to operate; it can be operated by small connecting-rods and levers. We have already worked out several installation plans and experienced no difficulty whatever. Regarding the wearing qualities of the gear, it is easily understood that when the friction is reduced the wear is reduced.

Lubrication

A sectional drawing of the tractor engine would show that the oil pump is in the center of the sump, that it is driven by spur gears from the main timing gears and runs slightly faster than crankshaft speed. The oiling system has been given very careful attention. Very heavy oil can be used in this engine with excellent results and also the thinnest oil obtainable; in fact, pure kerosene could be used and it would be impossible to burn out a bearing as long as some kind of oil was used. Poor lubricating oil does not do the engine any good in the long run and the use of it will reduce the life of the engine, but that is different from burning out bearings and ruining the engine. Past experience shows that there is little use in recommending a certain kind of oil for use in an engine; the owner cannot at all times obtain the oil he wishes and is therefore forced to use what he can get.

The Discussion

A Member:—How is the conclusion reached that in a twin-screw installation both engines should rotate in the same direction? Having arrived at such a conclusion, how is the camshaft designed to make a left-hand engine?

Joseph Van Blerck:—Some boat builders are already using engines which rotate in the same direction, and we find no difference in small boats. I can say no more than that it has been worked out in actual practice. This camshaft design has already been described. As soon as all boat builders cooperate so that all engines can be made for the same rotation, the cost of the engine will be reduced.

A Member:—If it is desired to run propellers in opposite directions and to build only one-hand engines, why cannot one engine be run through the reverse to go forward and in the forward position to reverse?

Mr. Van Blerck:—It would not be desirable to transmit the power through the reverse continuously. The power would be transmitted through the gears and would not allow quiet running. There is a certain amount of friction also to be avoided. There is a probable loss of 5 per cent through the gears.

A Member:—It is well known to every boat builder and boat handler that, if a twin-screw boat in which both engines turn in the same direction is allowed to run with the rudder free, even though it is built symmetrically, it will invariably turn to port. It is a fundamental law of physics that cannot be overcome.

Mr. Van Blerck:—If engine manufacturers were to build no left-hand engines for running propellers in opposite directions it would not be long before any difficulties which exist would be overcome. I believe that adequate allowance can be made.

A Member:—With a twin-screw installation on a fast boat it is best to have the propellers turn in opposite directions so that the opposed torques will balance each other. Perhaps this is a minor point, but it exists. Has the reverse gear been tried out?

Mr. Van Blerck:—Yes.

A Member:—I refer to checking the boat when it is going forward at fairly good speed?

Mr. Van Blerck:—We have tried it at full speed when the boat was going ahead and it reversed just as quickly; in fact, it reversed immediately, but the necessity for such an occasion would be very rare.

G. F. Crouch:—I recall an instance of this necessity. While in a small boat, a piece of driftwood jammed the rudder; the boat started straight for a dock. Fortunately, we hit one of the piles on the side; otherwise we would surely have gone under the dock. The boat had no reverse gear.

Mr. Van Blerck:—If two boats, one without a reverse gear and one with a reverse gear, were both run for a dock at full speed and then shut off to try to reverse at a certain distance from the dock, the boat without a reverse gear would be in the more dangerous situation.

Mr. Crouch:—The reverse gear is a decided improvement on the conventional type. A friend of mine found that he could not reverse until his boat had practically lost all forward motion. He then put a brake-band on the propeller-shaft.

Mr. Van Blerck:—We did that in the first try-out; it worked well. Then we took the brake-band off and it worked just as well. So, why put on a brake-band?

Erwin Chase:—I accompanied Mr. Van Blerck on the trials he mentioned and no one could require more of a reverse gear than he did. From going full speed ahead he went into full speed reverse and never missed. He had a brake-band on the shaft, but it was not necessary to use it. That was not a very fast boat; with a high-speed boat, in which the propeller-shaft runs very freely, it might be necessary to have a brake-band.

With both engines running the same way in a twin-screw installation, if both were right-hand wheels, the engine on the port side, having an arm from the center line of the boat to the center of the resistance of the boat, would counteract the arm of the engine on the other side. In other words, the increased component would not be any greater for the power than it would be with a single-screw vessel of the same power.

Mr. Van Blerck:—In regard to higher-speed boats, no matter how fast the engine is running, all that is necessary is to close the throttle; an engine will slow down quickly when it has no gas. When the propeller slows down to engine speed, then is the time to reverse. But with the high-speed boat, if the clutch is not thrown out and the reversal made at once, the propeller will gain speed and there may be some difficulty.

H. C. Gibson:—I had a boat 51 ft. long with 16-ft. beam; the engine was installed in a way similar to that in which an engine is installed in an automobile. We sat alongside the wheel and operated the clutch by foot power. We had the usual H gearshift arrangement. I used that boat for several years and it was always perfectly satisfactory. I never had any difficulty in picking up any of the gears, whether the engine was running fast on low gear or slow on high gear. I could make any change I wanted to make. That was a rather strenuous test, for the propeller was 36 in. in diameter.

Current Development of Automotive Industries

By J. E. SCHIPPER[1] (*Member*) BUFFALO SECTION PAPER

NOW that the two great automobile shows are over, we have a bird's-eye view of the year's developments. It is not only interesting but of the greatest importance to those of us who earn our livelihood from this great industry to take a survey of its economic and engineering aspects, in order that we may align ourselves with its future development.

Better performance and longer life due to improved design and materials distinguish the 1920 car from its predecessors. One of the healthiest signs in the industry is the uniform determination of practically every manufacturer in the field to improve the quality of his product. The high relative demand is only one reason for the higher prices. Besides this the higher labor and material costs are factors, but even were it not for these considerations, the better materials and workmanship would in themselves be causes of increased price. The realization of the fact that to stay in business it is necessary to build a good car is responsible for the effort of manufacturers to produce the best that is possible in the price-range served. Owners are demanding performance from the low-priced cars to just as great an extent as from the higher-priced products, the greatest differences being in the finish, upholstery and the size. This demand for acceleration and high-gear performance is greater now than it ever was, and it has forced the designer to extend himself in getting the highest possible output from the smallest possible units. This trend is very noticeable this year.

Prices are not going to come down yet. When the War Industries Board in the late summer of 1918 ordered the industry to be on a 100 per cent war basis by Jan. 1, 1919, it set in motion a chain of events which has had its effect upon every branch of automobile manufacture and sales and left an impression on the industry which will be noted for a long time to come. In the first place, production immediately started to decline, until it had dropped far below demand. Then came the armistice and an immediate scramble on the part of the factories to get back to a peace basis. Naturally, the first thought in the mind of the majority was that we would have the post-war car. The automobile manufacturer, it was thought, had during the war period prepared a design which would be ready for the public as soon as the war ended. It was therefore with a rather expectant attitude that the general public and most of the dealers approached the show in 1919 and awaited announcements during the early part of the year. But, this was not to be, and a moment's thought will readily show why. The engineering brains of the industry which in peace times would be focused on the drafting-board, in getting out new designs of car and truck, were busily engaged in ordnance, quartermaster and aircraft service. New tools were scarce and even if designs had been produced, tooling for production would have been impossible. The result was naturally just what would have been expected. The manufacturer, to meet to some extent the demands of the dealers who swarmed into his offices imploring him for cars, had to go back to where he left off and continue the old model with what few minor improvements had been decided upon before the armistice.

It was not easy for many of the manufacturers to get back to the peace-time production. Those who made war products that were closely related to their regular work were in an advantageous position, and naturally were soon grinding out a fairly reasonable production. On the other hand, factories which had taken out all of their own machinery and installed Government machinery in its place were in a bad situation. One company, for instance, had ripped out its entire upholstery department, had installed sewing machines and was busy turning out trousers for the soldiers. It is impossible to switch overnight from trousers to upholstery. Furthermore, the Government was not altogether too rapid about settling financial adjustments, and the outstanding capital was a sore handicap to many a plant that had invested heavily in special machinery and materials to carry on war work. All of this caused a delay in getting started, which not only allowed the pent-up demand to increase, but furnished a real opportunity for the engineering department, which had come back from the war, to concentrate on new designs. The result is that the 1920 cars, which have just made their appearance, and those which will break through the shell during the year of 1920 are the first real post-war products.

It is estimated that today there is a potential demand for 2,000,000 cars. This started to accumulate in 1918. Up through 1917, demand and supply were running a very close race, growing about uniformly, and there was a fairly easy absorption of the 1,800,000 cars produced that year. It was estimated that the production for 1918 would be 2,500,000. Instead of that only about 1,000,000 were produced, because of the war. Production totals for 1919 were 1,587,000. If demand had increased only as fast as normal, the 2,000,000 shortage would be a conservative estimate.

There is every reason to believe that the spring of 1920 will witness the greatest buying activity ever seen in the automobile field, just as this winter the demand for enclosed cars is, and will be, far in excess of the possible production of these vehicles. At present there are between 6,000,000 and 7,000,000 cars and trucks on the streets and roads of the country; in five years there should be 15,000,000. The extent to which the truck and passenger car will displace other forms of transportation is governed by only two things; the production of vehicles and the building of good roads.

In 1912 we had 325 manufacturers of passenger cars. Today we have less than 100 who are actually producing. But those who are in business now have seen the error in the ways of many who have failed, simply because the car was built for a price and dumped upon the market with consideration for the life and performance of the car given last place. It is recognized that the first requisite of an automobile manufacturer today is that he build a good automobile, even before he gets a good sales department or an efficient advertising manager, and

[1]Technical editor, Class Journal Co., Detroit.

it is this spirit and knowledge that are responsible for the trend toward improvement. The industry and the product are in a period of change. The consolidation of capital and the vast production required to build a low-priced car is forcing this business into the hands of a very few large producers and here it is likely to remain unless some inventor of tremendous genius can show a way to build a better car for less money. The new cars are automatically forced into a class selling for $1,500 and upward. It is in this field that we shall find the new cars, and there are many of them to come. At present there are probably a dozen new active organizations preparing to put out cars, some of them on a large scale.

Improvements in the cars are taking on definite shape, and it is not difficult to trace the probable trends for the next two years. Probably the most noticeable development will be the great replacement of the touring car by the sedan and other types of enclosed bodies in the higher-priced cars; and a vastly greater percentage of enclosed cars as compared with open in the lower-priced field. One company, for instance, which three years ago had an enclosed-car schedule of about 15 per cent, is now making 60 per cent enclosed cars. Others are following suit. The number of enclosed bodies sold is governed by the production, and this in turn has been materially affected by the labor troubles which are so widespread. In the past few weeks, for instance, the coal strike has greatly cut into the supply of glass, and the result is a curtailment. The upholstery and trimming departments of a number of factories have been affected also, but as fast as these troubles are cured, production will mount and the sedan will eventually occupy the place now held by the touring car.

Detachable-Head Engines

Probably the most significent improvement and tendency in engines from the repairman's as well as the manufacturer's standpoint is that of the detachable-head engine. This is notably on the increase and in fact it can be stated that not a single important new engine has been brought out this year which is not of this type. A particularly interesting detail in connection with the detachable head is the practice of putting small lips or lugs on the casting so that the repairman can remove it without damaging the gasket. With the ordinary flush type of top it was necessary to use a cold chisel to start the head after the studs had been removed, and this in every case necessitated the replacement of the head gasket. With the lips or lugs now cast on the head, it is possible to start its removal without damaging the gasket, which permits the use of the same gasket upon replacing the head. The detachable head, of course, provides greater accessibility for cleaning carbon and for inspecting the cylinder bore. It also permits the manufacturer to machine the combustion chambers accurately, thus securing absolutely even compression in all. With the overhead type of valve in connection with the detachable head, the entire valve assembly and rocker-arm units are removable together with the head, making it possible to work on a bench where the light is better and it is easier to use the desired tools.

In connection with the valve-in-head engine, some new ideas have been brought forward this year and incorporated on a great many of the new products. I refer particularly to the use of an open-sided cylinder-casting on the side on which are located the valve-rods. An aluminum cover-plate is put over the open side, which extends down into the crankcase, thus providing a clear opening from the head down to the case, allowing the oil spray to be thrown up to the overhead-valve mechanism and permitting it to operate in an oil mist. The criticism of noise which was generally directed against overhead-valve engines a few years ago, has been distinctly overcome in the new models.

A feature on all of the new engines is that the crankshaft and the crankshaft bearings are being made so heavy that it is probable that there will be fewer cases of bearing trouble in these new engines than ever before. It is not unusual for crankshafts to run up well over 2 in. on engines of the size which formerly employed 1¾-in. shafts. Pressure-feed oiling, which supplies the oil in sufficient quantities to cool as well as lubricate the bearings, has rendered these heavy shafts possible; and by their use the periodic vibration has been practically eliminated. On many of the new cars it is possible to remove the oil-pump from the exterior of the crankcase by withdrawing exterior cap-screws. This is a point which will be appreciated in cleaning out the oiling system and in overhauling the pump, particularly by those who have had in some cases to tear the engine down to reach the pump.

While aluminum pistons are used, they are not giving the trouble which was formerly experienced with them when it was attempted to cast aluminum pistons from exactly the same pattern as was used for an iron piston. It has been realized that the characteristics of the metal must be taken into consideration in manufacturing an aluminum piston, and the result is that the correct clearances have now been discovered and the correct method of stiffening the piston has been utilized to the elimination of trouble. It is of interest to note that where aluminum pistons were formerly used, first for their lightness and second for their heat-dissipating qualities, the situation has now been reversed and all of the aluminum pistons are of heavy section to secure the dissipating qualities, with lightness a secondary consideration. In fact, some of the new iron pistons are practically as light as the aluminum pistons. On the other hand, another company has this year returned to iron castings in place of aluminum for the cylinder blocks. However, these castings have been so carefully designed and are relatively so light that it is estimated that there is only 50 lb. difference per engine, due to the use of the iron cylinders. One engine uses an aluminum cylinder casting with what may be known as the wet-sleeve construction, as the cast-iron sleeve fits directly into the aluminum casting in such a way that the water is between the sleeve and casting and washes directly against the outside of the cast-iron liner. This construction is used in Europe to some extent, but this is the only American factory following this practice. Aluminum has been used very extensively by manufacturers generally this year. One new small six-cylinder car has an L-head engine with the detachable head, an aluminum casting incorporating the intake manifold. This exposes the lower part of the intake manifold to the heat of the combustion chamber and assists in vaporizing the gasoline.

Heating Devices for Intake Manifolds

The question of hot-spotting intake manifolds has continued to occupy the minds of engineers, but there has been an almost universal drifting toward the practice of arranging the hot-spot so that only the liquid or unvaporized portions of the fuel come in contact with it. In one type of design the inertia of the liquid or unvaporized fuel is made use of. These heavier particles have by their own mass sufficient kinetic energy to carry them across to the hot walls, whereas the vaporized por-

tions pass directly into the intake passage and to the valve ports. On one of the season's newer engines, the heavier portions by their own weight lie along the bottom of the intake passage, which is integral with the aluminum engine head, and these are vaporized by the heat of the combustion chamber. In another, an eight, the intake is exhaust-jacketed, and owing to the fact that the intake bridge is across the V between the engine blocks, there is a surging action of the gases to and fro from one block to the other, this giving the desired impinging effect to assist in vaporization. Another burns a portion of the fuel by means of a spark-plug inserted in the manifold, to heat the ingoing charge. Several other engine types allow the intake gases to pass across between the two central cylinders of the block. A new stock engine which will be used in a great many of the assembled cars, possibly twenty-five at the present writing, incorporates an exhaust-jacketed manifold, the intake being cast integrally with the exhaust and in contact with it to a certain degree to assist vaporization.

Some of the engine details which are particularly noticeable are the trend toward larger valves and ports, the use of die-cast babbitt bearings for the rods and main bearings, chain drive for the timing-gears, and more complete distribution of the oil pressure feed to different parts of the engine. The use of the die-cast bearings makes it necessary in a great many instances to return the rods or main bearings direct to the factory for replacement, unless the repairman is equipped to do his own die-casting on a mandrel. This is not an easy job to handle without special equipment and consequently this new construction will result in handling bearing repairs by replacing the entire assembly, with allowance being made for the part turned in. Iron-backed bearings instead of bronze-backed are claimed to have advantages.

Clutches do not show much change this year as far as construction is concerned. There has, however, been a tendency toward the adoption of the dry-plate type by a great many manufacturers. One three-plate type is used on nearly sixty makes. The number of plates utilized runs all the way from three to seventeen; three, five, eleven and seventeen being the predominating numbers. An attempt has been made by some of the manufacturers to increase the leverage of the clutch pedal to make the car easier to handle, particularly by women, and in this respect there are some notably good designs. Short travel at the clutch for disengagement is, of course, easier with fewer plates.

Unit powerplant construction has remained popular. Only one new car to be made in quantities this year does not use it. The Hotchkiss drive continues to be popular, but recently there has been some talk among engineers of dropping it in an attempt to secure easier spring suspension. Two new cars exhibited at New York for the first time had torque members. One has a tube which encloses the entire drive, and a triangular stay layout from the front end of the torque tube back to the outer extremities of the rear axle. The other has a torque arm and radius-rods.

Wheels and Axles

Semi-floating rear axles are gaining in popularity and there is a tendency toward redesigning the axle for lightness. Some of the newer axles have bearings on both ends of the pinion shaft, which tends toward stiffness and also permits of a single pinion-shaft carrier which can be removed as a unit. All of the newer types of axle have very accessible adjustments for the pinions and ring-gear mesh, from the outside of the axles. The employment of aluminum axle housings can be expected in the near future. Castings have already been introduced which are said to be satisfactory for this part of the chassis. Although this is more expensive than the present construction, it results in a material reduction of unsprung weight, which a great many manufacturers deem of the utmost importance.

The use of aluminum wheels is also among the future possibilities, the new castings shown at the New York and Chicago exhibits having attracted notable interest. It is stated that it will be possible to provide wheels for a 3000-lb. touring car weighing but 19 lb. apiece, which of course would make a material reduction over present types, although no doubt much more expensive.

There has been some lengthening of wheelbase due to a desire to increase body room. On the other hand, some manufacturers have shortened the wheelbase and yet accomplished a great deal in the bodies. The most notable instance of this is, of course, the overhung frame. Frame side members have been deepened almost universally and the transverse members have been more firmly gusseted than ever. In the chassis oiling system there has been an increase in the use of the high-pressure grease-gun type of lubrication, which is used on a great many cars now as stock equipment. The oil-cups have continued to increase at the expense of the ordinary type of grease-cups. One car at the New York show with a centralized system of chassis lubrication excited a great deal of interest, and it may be that some of the features incorporated in this will find their way into other chassis. Some of the new models in the lower-priced class have gone to the transmission-shaft brake. Whether this will be a definite tendency remains to be seen. It certainly results in cleaning up the chassis and freeing it from an extra set of brake-rods, and also provides an efficient brake for emergency use. In all cases where the transmission brake has been installed, it has been for the hand-brake and not the foot-brake. The straight-line type of body predominates this year. There is a tendency toward the abandonment of the bevel edge which became popular two years ago. A sharp angular break at the hood, continued back to the rear end of the body, is noticeable in a great many of the new types, and it might be called the distinguishing lines of the 1920 products.

Pneumatic Tires for Trucks

In outlining the engineering trends of truck design, the paramount feature is the tendency toward pneumatic equipment in the capacities above 2-ton. If this development goes forward at the rate predicted by the big tire manufacturers and a great many of the truck builders, it will have a radical effect on truck design during the next two years. Pneumatic-tire sizes above 12 in. in diameter have already been developed and it remains to be seen whether the truck manufacturers will use them on the heavier-capacity trucks. If they do, it will mean higher speed and lighter chassis parts and in general a higher pay-load proportion as compared with the weight of the truck. Up to date, the development work along these lines has been done by the tire companies to a greater extent than by the truck companies. During the coming year the experimental departments of the larger truck companies will no doubt go into the matter in even greater detail than the tire manufacturers have during the past year. The establishment of long-distance hauling at high rates of speed on heavy-capacity vehicles has practically compelled the use of the pneumatic tire for this type of service at least, and the limitations of the truck engine and chassis designed for solid-tire work

have soon been met when the truck was mounted on pneumatic tires. Changes in the speed range and gear ratios will be only a minor part of the complete overhauling in design which can be expected from this important development.

Looking over the new models brought out during 1919, the fact which impresses one most is the marked effect upon commercial designs made by the Class B military truck. That this truck was a product of the best that the combined efforts of truck engineers were capable is the belief of a great many of the truck manufacturers, if the eagerness with which they have adopted a great many of the features of this truck is any criterion. To give an example of the effect of the military-truck design on commercial practice, it is only necessary to study the gearboxes fitted during the past year. In the Class B military truck a four-speed gearbox was used with an extremely low gear ratio to provide a practically non-stallable vehicle. This same feature has been incorporated on so many of the trucks for 1920 that it has changed the percentage tables so that the average equipment on trucks of 2, 2½, 3½ and 5-ton capacities is a four-speed gearbox for 1920, whereas it was three-speed for 1919.

The economic situation in the field of small-capacity trucks is not as tense as it is in the production of the low-priced passenger-car. A truck manufacturer with a smaller production can, in common parlance, "get away" with a fairly small production. This is evident by the fact that there are ninety different models of 1½-ton truck on the market, and seventy-three models of 2 ton. The 1½-ton truck is the most popular type, filling as it does the widest field. However, there is a strong tendency toward an increased number of 2-ton trucks, particularly in territories where it is possible by means of good roads to develop fairly long hauls. The increased use of the pneumatic tire on the 2-ton truck is also promoting the popularity of this model to a considerable extent.

Truck Engine Development

A great many truck engineers believe we are on the eve of important engine developments in the truck field. There is no doubt that these developments will be largely due to the higher speeds demanded of trucks. With the fitting of pneumatic tires to the 2 and 3½-ton models, the average speeds have risen from 12 to 18, and even to 25 m.p.h. in the sparsely-settled districts. This may prove to be too high a speed range for the type of truck engine which has come to be associated with the solid tires. These engines, running at 1200 to 1400 r.p.m., may not be of a sufficient speed to function efficiently in connection with the gear ratio demanded with the pneumatic tires. It is possible that truck engines will peak at nearer 1800 and 2000 r.p.m. if developments in the pneumatic tire are carried forward. It is very probable that on these higher-speed engines the governor equipment will be modified, and on certain types of service not be used. As a matter of fact, the development in this line is controlled very largely by the building of good roads. The future development of the truck can almost be said to depend upon the road situation throughout the country.

At the present time there are about 2,500,000 miles of good roads in the United States, of which less than 300,000 miles are hard-surfaced. This condition will no doubt change rapidly during the next few years on account of the big appropriations made, not only by the States individually, but by the Federal Government for the development of national highway systems.

The total money available for road building throughout the United States is about $2,000,000,000, of which about $400,000,000 is available for the development of the national highway system. This immense amount of money could not be expended in less than three years with present labor and material conditions. The fact, however, that referendums on road appropriations are practically always carried shows that there is a marked tendency throughout the country for the development of highways.

Mechanically, there have been very few changes in truck engines during the past year. Manifolds have been redesigned to some extent so that the intake is partially heated by the exhaust to assist in vaporization in cold weather, and also to reduce the length of time required to warm a cold engine. Another important feature is the marked tendency toward the fitting of the electrical equipment on trucks. There are six ½-ton models on the market for 1920; all of these are furnished with electric lighting and two have starters as standard equipment. Of the twelve ¾-ton models, five have electric starting, lighting and ignition. In the 1-ton size, two out of ten are furnished with electric lighting which has been specified as standard equipment, while the other eight models provide it at an extra cost varying from $35 to $125. Of eleven other 1-ton models, which can be had with electric starting and lighting, only one model has it as standard equipment. The others furnish it at extra charge. On the heavier capacities there is an increasing tendency toward fitting full electric equipment. Another development in truck engines, which will follow along the line of developments in the passenger-car type, is the use of temperature control. At present there is only one company fitting a thermostat to its truck, but it is likely that others will follow suit during this year.

In the development of clutches there is not much new to relate. The dry-disk clutch, which gained supremacy in the field during 1919, still carries off the palm for 1920 as most popular. Clutches of this design have gone upward of 75,000 miles without adjustment on passenger cars, and are giving equally as good satisfaction on trucks even in the heavier sizes. Transmission gearsets have not varied in type, except for the addition of the fourth speed. There have been no noticeable tendencies in design in this part of the truck; the gearset is more or less a standard matter.

The final drive situation shows a gain for the internal gear when considered by models. Considered by production, the status remains about the same as last year, except for a drop in the use of chain-driven vehicles. Or, if considered by models, which is the true way of determining popularity, each model can be considered a ballot by the engineering department of the company producing it, the internal-gear drive has grown to 26 per cent, as compared to 19 per cent in 1919. The worm drive has remained about the same, the percentage being 66½ per cent for 1919 and 65 per cent for 1920. The gain of the internal gear has been at the expense of the chain and bevel drives, these having dropped from 8¾ to 5 per cent and from 5 to 3 per cent respectively. There are many, however, who predict that there will be a marked increase in the use of the bevel drive if the pneumatic tires become practically universal on the 2 and 3½-ton sizes.

Production Statistics

As far as truck prices are concerned, there is very little increase over the average price of 1919, considering the labor and material situation. The percentage of increase, as a matter of fact, is 4.3 on all models, and the largest price increase is 12.4 per cent on trucks of 3-tons capac-

ity. The prospect for a reduction in truck prices is not in sight; in fact, it may be that increases in prices will be prevalent during the early part of 1920. It is quite within the realms of possibility that prices will begin to decline toward the end of 1920. Production will increase. The year 1920 will probably be the largest in the history of the industry. The year 1919 has proved to be the largest so far. The production for 1919 was 305,142; for 1918 it was 250,000 and for 1917, 190,000.

In spite of the fact that the industry was practically on a war basis Jan. 1, 1919, making possible only a small production during the first three months of recovery, 1,587,000 cars and 305,000 trucks were made during the year. This is only slightly less than 1917, a normal peace-time year, when 1,741,000 cars and 128,000 trucks were manufactured. Thus the passenger-car business of 1919 can be said to have been practically back to normal and the truck business nearly three times that of the last normal peace-time year. The mere figures of production, however, do not begin to tell the story. In spite of the large output, the supply of cars was far below the demand, and it is conservatively estimated that the year of 1919 has turned over to 1920 an unsupplied demand for 2,000,000 cars. From the motor-truck angle, the opening of 1920 saw unfolded the brightest prospects that have ever confronted the business. Turning our attention again to the passenger-car industry, we find that it has become one of the greatest in the world. The output of cars for 1919 was valued, from a wholesale standpoint, at $1,400,000,000, an average of $882 per car. If production had kept pace with demand, the value of cars produced would have been $3,000,000,000, with cash-in-hand buyers, both wholesale and retail, to be found all over the country and in fact all over the world, waiting for the cars of American manufacture.

The year 1920 has two big problems. The first that of production, and the second, of merchandising. The problem of production is governed almost solely by labor. It is the labor condition which holds up our supply of glass, steel or other basic materials, without which the automobile cannot be built. Remove this throttle, and production will jump ahead at an amazing rate. The waiting, ready demand keeps moving ahead so rapidly at present that this factor of production overshadows that of merchandising, and yet the day of the latter is so surely coming that only the most short-sighted manufacturer is not making ready and laying his plans for the day when a well-organized distribution scheme and personnel is required. Although at present subdued under the avalanche of demand, both domestic and foreign, the merchandising fabric which was destroyed by war conditions is rapidly being repaired. Intensive selling methods will return to use, and the country will be again dotted with dealers and sub-dealers who for mere lack of cars were forced to suspend temporarily.

Returning to the production angle, the automobile industry begins to loom as a candidate for first place among the manufacturing industries of the country. Today it is second only to steel and, with the great amount of other products involved and the other industries directly and indirectly affected by automobile manufacture, it stands today as probably the most dominant factor in American life. Certainly the effect of the pent-up demand was felt in the spring of 1919, when cars were at such a premium that options on delivery were selling for big prices. The world is scrambling for cars; therefore, every factory is going to make every possible effort during 1920 to turn out all the cars it can. This situation is bound to cause the creation of new companies. The parts manufacturers are so overcrowded with orders that they cannot, in many instances, take on more orders. The result is that the next year will probably witness a marked increase in the manufacture of parts for sale to the trade. This in turn will cause an increase in the assembled-car business and a corresponding augmentation of the volume of the industry.

The prediction of increased production is made unanimously by the executive heads of factories who have made a careful study of this situation. An average of the estimates for the future indicates a production of 2,250,000 cars for 1920, with 200,000 to 300,000 increase per year for five years thereafter. Certain it is that the old bugaboo, commonly termed the saturation point, has ceased to be held up with trembling hands by the pessimistic.

The Labor Outlook

All of this production problem, however, depends upon labor conditions. There are no more progressive organizations in the world than the American automobile manufacturers. Taken collectively, there are no industries in which the workmen are better paid or more fairly dealt with. Like all other industries, that of automobile manufacture has come through a delicate period in 1919, but 1920 is faced with the confidence that the policy of fair dealing uniformly adopted will keep the automobile industry as free as any other from labor trouble. In fact, the general impression is that we are emerging from the period of unrest. Shortage of coal and steel materially affected production during December. In fact, had the coal situation not cleared up when it did, a serious shutdown would have resulted. As it was, many of the factories were compelled to run on part time, and others saved themselves from a complete shutdown by using automobile and other gasoline engines to run their machines.

All of these conditions materially affect the 1920 production situation. Passenger cars have been standardized by the Society of Automotive Engineers to such a degree that an interchange of parts that is not possible in any other field is currently practised. This feature has been the source of envy and amazement to the European manufacturer, who, in his desire to maintain individuality, lost sight of the possibilities of greatly increased national production through standardization. It makes the work of assembling cars for export so much more simple that it is going to be of direct influence in increasing the foreign market for American cars. This foreign demand is so great and the attractions of a world market are so pronounced that all manufacturers have determined to enter the lists for foreign trade. The result of this is that most factories are going to set aside a certain percentage of their production for export regardless of the domestic demand. This is no more than right. It is a patriotic duty, as a matter of fact, to help the United States to establish its foreign trade, and not the least of our exports during the coming years will be automobiles and parts.

The truck industry offers possibilities that bring it, in its particular field, into as great promise as that of the passenger car. During the year 1919 the United States manufactured 305,142 trucks. Production schedules for 1920 call for 430,000 trucks. It is estimated that this will be cut to 370,000 when the final check comes at the end of the year. This drop below the schedule production will be due to lack of materials, and this in turn largely because of direct or indirect labor influence. The fear that the left-over trucks from the Quartermaster and

Motor Transport departments would have a material effect on the market has passed, as far as the manufacturer is concerned. A year ago, when we were all making predictions as to the number of trucks to be turned out in 1919, we said that it would amount to not more than 290,000. The prediction was based upon the upset condition of the factories at that time. The quick rally was a surprise to those who are most familiar with the industry, and the actual production exceeded the estimate by 15,000.

The use of the motor truck to replace the freight car for certain classes of work has proved a marked success. The number of companies which are going into both urban and interurban transportation is growing day by day. Trucks are operating on railroad schedules, and indeed have proved to be more dependable on a time basis than the steam roads have ever been. There are truck lines that hold their schedules so closely that they start on the dot, regardless of whether they have a load at the time or not. This efficient transportation service will pave the way for future truck business to such an extent that we may look to the time when the national means of transportation in this country will be the truck, in spite of our great railroad mileage.

IS THE MOTOR TRUCK THE RAILROAD'S NEMESIS?

WHEN motor-bus lines first began to cut into the passenger business of both railroad and traction lines, engineers proved that rubber and gasoline never could compete with steel and coal. Later, it was found passengers were willing to pay for the additional pleasure and comfort. There was also an important element of cost overlooked in the early computations. While the railroad and traction companies were forced to buy their rights-of-way and construct and maintain their tracks, the public provided the rights-of-way for the motor lines and defrayed the cost of maintenance.

This factor of a "free track" operates in connection with both freight and passengers, and, while the comfort of freight need not be considered, the packing must. Motor trucks, making a door to door delivery, transport freight with less handling than the railroads and, consequently, with less packing. Speaking quite generally, it is reasonable to assume that the business which will flow to motor-truck lines is the traffic wherein the packing cost bears a high ratio to the carrying cost, and this limitation would leave the railroads practically all their long-haul business.

Trucks to Replace Rails

C. A. Morse, assistant director of operation in charge of engineering and maintenance for the Railroad Administration, speaking on this subject before the New York Railroad Club, said

> Where heretofore development of the country for 50 miles either side of a trunk line of railroad has required the construction of light branch lines, it is a question to be considered seriously whether this policy should be continued or whether good wagon roads should be constructed and the products of farms and passenger travel should not be handled by motor trucks and automobiles to the main line. Taken alone and considered as a unit practically none of these small branch lines pay expenses, but as gatherers of freight and passengers to increase density of traffic on the main lines they are sources of profit. As, however, the traffic gathered by them is turned over to the main line with a deficit attached which has to be overcome during the main-line movement before any profit is made, it would be a decided advantage if this traffic could be delivered to the trunk line by the motor truck, tractor and automobile without this bill of expense attached.

Representative Esch, chairman of the House Commerce Committee, discussing the same subject, said

> Development of motor-truck routes as the short-line railroads have been developed, as feeders to the railroads, with through bills of lading and a division of the through rates, is well worthy the consideration of Congress. The use of motor-truck routes as an aid in transportation is in process of evolution, and I believe it will be a big factor in the future.

Unprofitable Traffic

Motor-truck competition will affect the volume of traffic of various roads in varying degree, but it is likely to be, speaking broadly, traffic that is unprofitable for the roads.

Unless freight is moving in heavy and fairly steady volume between two given points, shipments for less than 100 miles or a division are unprofitable. The tariff on a case of shoes shipped 50 miles would not cover the cost of coal consumed in stopping and starting a train, not to mention the wear on the rails and wheels and the wages of an engineer, fireman, conductor and two brakemen.

Short hauls on less than carload lots when made between large cities and their suburbs are not only unprofitable but they involve heavy losses.

The future of the motor truck as a freight carrier within limitations seems assured. In suburban traffic, it has stood the test of several years' time, and in this field it will meet encouragement rather than obstruction from the railroads. In handling small lots over short hauls, it will likely make further inroads on railroad business, but at no great financial loss to the railroads.—*The Magazine of Wall Street.*

OIL REFINERY STATISTICS

THE oil runs to the refineries of the United States for the year 1919 were 361,520,153 bbl. of crude oil, or 990,466 bbl. per day. In December, 1919, the refineries in operation had a daily capacity of 1,356,355 bbl. per day, whereas the daily run of crude oil to the stills was 1,046,052 bbl., indicating that they are running at only 73 per cent of their rated capacity. Refineries of an additional 174,210-bbl. capacity per day were idle, while refineries totaling a capacity of 263,000 bbl. daily were under construction.

CAUSES OF INFLATION

ASSISTANT Secretary of Treasury Leffingwell stated in an address before the Academy of Political Science recently that the three principal causes for the existing inflation and the resultant unrest were world inflation and internationalization of prices, heavy Government expenditures and Government interference with business and a reaction from the necessity for saving during the war period and the consequent waste among the great majority of the people not only here but abroad.

The Essentials of High-Grade Steel Manufacture

By W. R. SHIMER[1] (*Non-Member*)

INDIANA SECTION PAPER *Illustrated with* PHOTOGRAPHS

THE manufacture of high-grade automobile steels begins with the selection of proper raw materials. The larger manufacturer of today owns and controls his ore, coal and limestone properties, and, therefore, is in a position to obtain a uniform quality of raw materials, enabling him to produce finished steel products of uniform quality. When it is necessary for a steel manufacturer to purchase raw materials from the market he many times must accept ore, coke and limestone of varying quality, thereby making it difficult for him to produce pig iron of uniform quality with a corresponding quality of steel products.

The majority of steel made for the automobile industry today is manufactured by the basic open-hearth process. Crucible and electric furnace steel is used to a certain extent, but only for very special purposes where the tonnage is relatively small and special properties are desired. These latter grades of steel are expensive and on this account are unwarranted for use for the bulk of automobile parts. The physical charge in the open-hearth furnace consists of pig iron and steel scrap in approximately equal proportions with a certain amount of ore and limestone.

The chemical charge is approximately.

	Per cent.
Silicon	0.75 to 0.90
Phosphorus	0.10 to 0.11
Manganese	1.00
Carbon	1.75 to 2.00
Iron	96.00 to 97.00
Sulphur	About 0.070

All of these elements, except sulphur, give the furnaceman practically no trouble, as he can reduce silicon, phosphorus, carbon, etc., to any desired percentage. Sulphur is the only element which causes any difficulty and must be controlled by the use of as low-sulphur scrap and pig iron as it is possible to obtain. Due to present labor conditions in the coal mines and to the diverting of proper steel-making coals by the Railroad Administration, the steel maker is very much handicapped and must accept many times, high-sulphur coal, or none at all, and the sulphur in the steel is increased on this account. There is the old adage that "the effect of phosphorus in steel is up to the consumer and sulphur up to the maker." In other words, phosphorus is a greater hardener than carbon and high phosphorus tends to reduce ductility in the higher carbon steels. Sulphur is considered the red short element and need not be feared by the consumer as long as the heat of steel forges or rolls satisfactorily and the finished product is free from surface defects.

MAKING AND TESTING THE STEEL

Pig iron is sometimes charged in the open-hearth in the molten condition and at other times in the form of cold pig, steel scrap being used in both cases. Immediately after the materials charged are melted, the furnaceman takes a small quick test from the furnace with a spoon and casts it into a small ingot called the quick-test ingot. This ingot is cooled and fractured and from the appearance of the fracture he judges the approximate carbon content of the bath. Half of this test ingot is then sent to the laboratory, drilled and analyzed for carbon, manganese, phosphorus and sulphur. If the heat is to be nickel steel and nickel-steel scrap has been used, the nickel also is determined from the quick test in order

FIG. 1

Percentage of Carbon as Judged by the Melter				
0.15	0.45	0.60	1.00	1.40
Percentage of Carbon as Determined by a Laboratory Analysis				
0.14	0.43	0.55	0.98	1.34

that the necessary addition to meet the alloy requirements can be calculated. Subsequent tests are taken from the furnace by the furnaceman at intervals in the process of refining until the heat is down to the required carbon content, by which time the phosphorus has also been lowered as well as the other elements, and the heat is then ready for the final additions. Ferromanganese is added to the furnace in amounts depending upon the results reported by the laboratory on the last quick test. Ferrosilicon in basic open-hearth steels is added to the ladle, having first been crushed up very fine. The addition is made to the stream of metal coming from the furnace as it enters the ladle. Ferrosilicon cannot be added to the furnace as it would attack the basic furnace lining.

Fig. 1 shows a series of fractures of the quick-test ingots taken during the melting of an open-hearth heat, commencing with the one taken immediately after the bath is melted and including the final test. The carbon content as judged by the melter and also as determined by the laboratory is shown with each fracture. It will be noted how closely the carbon can be judged by the melter by the apparance of the fracture. The highest carbon test has the finest grained fracture, which becomes more coarse-grained as the carbon content decreases. An experienced furnaceman can estimate the carbon from the fracture with nearly the same accuracy as that of a chemical determination, especially when working with carbon steel heats. It takes an especially well experienced furnaceman to judge the carbon from quick tests, from nickel, nickel-chrome or other alloy steel heats.

When the heat of steel is refined and the desired com-

[1]Metallurgist, Bethlehem Steel Co., Bethlehem, Pa.

position obtained by eliminating some elements and adding others such as manganese, silicon and other alloys to meet the specifications, it is tapped into a ladle. The slag also runs into the ladle, floating immediately to the top of the molten steel on account of being much lighter in weight than the latter. It seems to be the impression of many that microscopic non-metallic inclusions in steel originate from slag in the furnace or the ladle. As evidence that this is not the source of such inclusions, I will cite the following examples:

A number of times after a ladle of steel was empty, at the time when both slag and steel were dripping from the ladle nozzle together, a small test ingot, a 2½-in. cube, was taken in an attempt to obtain a small ingot contaminated with ladle slag. The material cast into this small mold solidified the instant the mold was filled. It was found that the upper half of each one of these small ingots was slag and the lower half a solid steel casting, the slag having separated from the steel immediately, on account of its lighter weight. These small ingots were then split, polished and etched and subjected to a very careful microscopic examination over the entire surface and found to be entirely free from slag. Fig. 2 shows such a small ingot after splitting in half and polishing and etching. There were several blowholes in the ingot shown in this illustration whose sides were silvery white, containing no slag. Such evidence as this convinces one that the non-metallic inclusions in steel do not originate from furnace or ladle slag, since the latter separates from the steel as readily as a cork floats on water.

Furnace and ladle slags are composed of oxides of iron, aluminum, calcium, silicon, manganese, etc., while microscopic non-metallic inclusions in steel are mostly sulphides of iron and manganese, and at times very small amounts of silicates of manganese and iron. These latter inclusions are due to foreign matter from the molds or other external source. The sulphide inclusions originate from the reaction which occurs in the molten metal in the ingot before solidification, and become imprisoned during solidification. Their size and quantity increase with the size of the ingot; that is, the larger ingots remain molten longer and sulphides have more time to segregate in them than in the smaller ingots. If the steel in the mold solidified the instant it was cast, there would be no sulphide inclusions of appreciable size, if any. Additional evidence is that non-metallic inclusions in steel contain no lime, whereas furnace and ladle slags always contain lime.

Pouring the Ingot

The pouring of ingots is a most important factor in the manufacture of steel. Steel should be poured in the ingot mold as slowly as possible so that the metal can solidify from the bottom upward, enabling the top to remain molten until the last. The practice of box pouring produces clean ingots with very little pipe, since by this method two ingots are generally poured at a time, therefore permitting slow pouring; also the pressure of the stream from the box is much less than when poured direct from the ladle, and the metal cools from 80 to 100 deg. fahr. when run through a box. Splashing of the stream against the sides of the molds is prevented to a great extent, thereby improving the surface of the ingot as well as the rolling qualities and giving consequent freedom from cracks and scabs. There are other methods of pouring steel ingots which have advantages. Some manufacturers bottom pour by teeming the metal into a central runner to which runners are connected to a series of molds and the molds fed from the bottom. This practice improves the surface of the ingot, permits slow pouring and improves rolling properties.

To overcome pipe in bottom-poured ingots it is necessary that the molds be equipped with satisfactory sinkheads to keep the tops molten until the metal in the body of the ingot solidifies. The method of pouring, whether box-poured, bottom-poured, or poured direct from the ladle, depends upon the grade of steel being made and the practice with which the manufacturer has met the most success. Each steel maker swears by his particular method and obtains good results, as his pouring method is particularly adapted to the grades of steel he manufactures and his organization has been trained to carry on the method successfully.

It is of the utmost importance that high-grade steels be refined with extreme care and that all additions possible be made in the furnace. To be assured that a heat of steel is of uniform analysis, the quality manufacturer takes three heat-tests from the ladle, one at the beginning of the ladle pour, one at the middle and one at the end. These tests are analyzed by the laboratory and the heat is not applied if the composition is not consistent throughout.

After careful refining, a good heat of steel can be spoiled after leaving the furnace by casting into dirty or rusted molds or old molds having depressions or cracks in which the ingot will become held when it shrinks in cooling, causing cracks and resultant tears in the ingot when rolled. The molds should always be in good condition and slurried with a wash to clean all dirt and scale and prevent the metal which may splash against the sides in pouring from adhering to the mold surface. With the clean mold extreme care should be exercised in casting and sinkheads should be placed on the top of the molds to keep the upper part of the ingot molten so that the pipe can be retained in the upper part of the ingot and later discarded at the blooming mill shear.

Fig. 3 shows two split ingots from the same heat of steel, that at the left, having been cast with a sinkhead and the other without. The difference between these ingots is evident, the former having much less pipe than the other. The ingots should then be stripped while still hot and charged vertically into the soaking pits within a short time thereafter, there to be heated carefully to the proper rolling temperature and special care taken to soak them through thoroughly before rolling. The ingots are then rolled down on a blooming mill to about 9 in. square and pass on to the hot shears where the top and bottom discards are cut and the sound portions cut to length for subsequent rolling on the smaller mills. The shearing of the top discard from the blooms is witnessed by an experienced man who can detect by the appearance of the sheared surface whether the bloom is free of pipe, and he instructs the shearman to continue shearing off additional metal until he is absolutely assured that all of the piped steel has been discarded. In the case of steels of a special nature or of a composition having a greater tendency to develop pipe, the ends of the cold blooms from such heats are cold fractured in the billet yard to give assurance of their freedom from pipe.

When cold the blooms are carefully examined for surface defects such as seams, tears due to ingot cracks and scabs resulting from poor molds and splashing of the metal while pouring. With good practice there should be but few of these defects. All of the surface defects are chipped out carefully, first, with a U-shaped gouge that produces, at times, rather deep grooves in the bloom which are then flared out on both sides with a flat chisel to prevent any lapping of such a groove in the subsequent

FIG. 2

rolling operations, which may cause defects of the same nature as a seam. The method of chipping should always be carefully checked up on this account.

Samples for analysis are taken from the various blooms of each heat and analyzed by the laboratory as an additional check on the uniformity of the heat, as well as to insure that there were no mix-ups in heats by the mill. The heat number is stamped on each bloom at the hot shears so that they can be identified at any time in the billet yard or on the chipping beds. This also prevents the chance of a mix-up occurring during charging in the reheating furnace. The blooms of approximately 9-in. square section after chipping, are broken down to billets 2 to 4 in. square, which are again inspected, chipped if necessary and then reheated in continuous furnaces for rolling into finished sizes.

HEAT-TREATMENT AND INSPECTION

The heat-treatment of alloy steels actually commences with the ingot after casting. If the mold is stripped too soon after casting and the ingot heated and rolled too soon, there is danger of obtaining what is termed a green ingot and the finished product from such an ingot is not what it should be. A sufficient interval between casting and charging an ingot in the soaking pits should be allowed to be sure that the interior metal has solidified. Alloy-steel ingots containing fairly high percentages of hardening elements, if allowed to cool in the air to atmospheric temperature, invariably develop shrinkage cracks which may produce defects in blooms at times so bad that it may not be worth while attempting to chip them out, it being more economical to scrap such product. Certain alloy-steel blooms containing high percentages of hardening elements are annealed immediately after rolling, as a safeguard against the serious strains that would be set up, leading to cracks, if the blooms were permitted to cool rapidly in the air from the rolling temperature. The finished bars of sensitive composition are carefully handled after rolling, to prevent cooling strains, and are not spaced on the hot beds but placed against each other to retard cooling. The finished bars of over, say, 0.25 to 0.30 per cent carbon, are carefully annealed, the annealing temperature depending upon the composition, and after a thorough soaking at the proper temperature, are cooled slowly in the furnace and afterward put through roller straightening machines when they are ready for inspection.

The majority of steel bars of under 0.25 per cent carbon for the automobile industry are cold-drawn, or rough-turned, for automatic-machine work. Before cold-drawing the bars are pickled and then inspected for seams. Most of this grade is used for case-hardening. These lower carbon steels are generally not annealed, on account of the tendency to become too soft for easy machining qualities. Steels which are dead-soft from composition should not be annealed and cold-drawing hardens them sufficiently to impart good cutting qualities.

Inspection is a most important factor and the inspection department head should not report to or be any part of the mill organization. He should report to the general superintendent or manager, and his decision must be final. The attitude of the works inspector should be that of the consumer and it is beneficial to both the manufacturer and the consumer to have unsatisfactory steel rejected at the works of the former. This not only saves freight, cost of handling and reputation, but when the steel is rejected at the mill it is brought to the attention of the entire mill organization and makes a stronger impression on them, giving the mill superintendent opportunity to discover faults in manufacture in time to prevent a reoccurrence, whereas, if the steel is rejected by the consumer, the first information received by the mill superintendent is by letter, which does not make the same impression either upon him or his organization, and when the steel is finally returned months later it is rusted, or the matter forgotten, and the mill does not have the same opportunity to examine it. When steel is rejected before shipment by the works inspector, remedies can be applied at once rather than months later, during which period much unsatisfactory steel may be shipped before the manufacturer knows of the unsatisfactory product. There is no use concealing the fact that an inspector under the management of the mill superintendent will be more lenient and inclined to try to please his superior by taking chances on material which may not be up to par. Such chances are not taken when the inspection department is

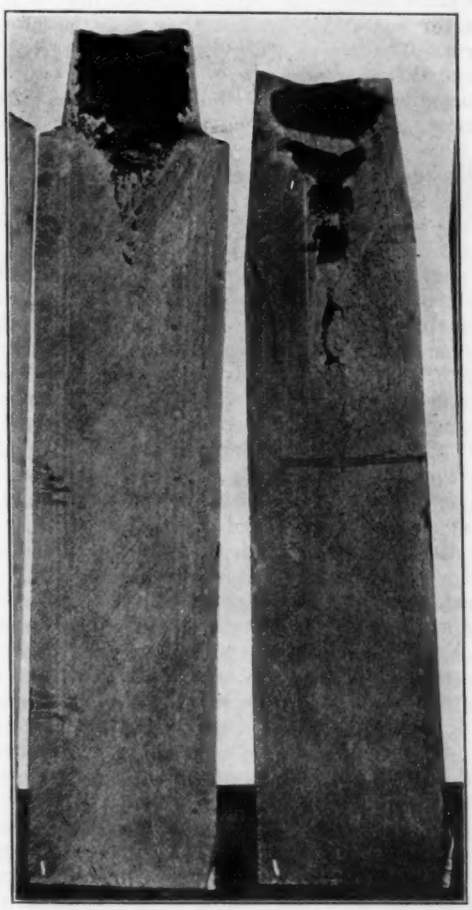


FIG. 3

separate from the mill organization, and therefore the manufacturer and consumer are mutually benefited.

It is of considerable advantage to both tne works inspector and the consumer if the former has opportunity to become acquainted with the details of manufacture of the consumer of the steel. He should have information, for example, as to machining tolerances, the number of parts to be machined from the bar, whether the finished part is to be solid or hollow, whether the consumer intends to heat-treat the part and how, or contemplates an upsetting operation, and any other such data. No steel manufacturer obtains 100 per cent good product, and information along the lines indicated will enable the inspector to work more intelligently. The inspector may reject material for very shallow surface seams in bar stock on which the consumer has sufficient machining tolerances to clean up such defects. The point I wish to bring out is that in our country we waste too much good material and every effort should be made to reduce this waste to a minimum, whether it be steel or any other commodity. The manufacturer desires the information mentioned not to see how much bad steel he can ship, but with the idea of reducing unnecessary waste.

Improperly heat-treated alloy steels are inferior to properly heat-treated simple steels. The critical points of two different heats of steel of identically the same composition may vary as much as 30 deg. fahr. This can no doubt be attributed to the usual variation in either the finishing temperature or the rate of cooling from the finishing temperature. I have no data as to whether such variations in critical points are found in heats of steel of the same composition after normalizing; it is possible that after such a treatment they may be more nearly uniform. Therefore, different heats of steel, if treated in the condition in which they are shipped from the mill, not normalized, furnished under the same chemical requirements, will not respond to one standard heat-treatment, and it is therefore good practice for the consumer to determine the proper heat-treatment for each heat of steel he receives. Although the determination of the critical point of each heat is of value, the quenching temperature will increase with the increase in the size of the part to be treated. A very good commercial method for determining the ideal quenching temperature of a heat of steel is to take a number of short bars from it, nick them, and subject them to various quenching temperatures, beginning slightly below the critical point and quenching to 100 deg. or more above it, increasing each quenching temperature by about 25-deg. increments. The bars should then be cold-fractured and the quenching temperature of the bar having the finest grained fracture should be used as the temperature at which the bars from the heat should be quenched. This temperature will, of course, vary somewhat with the size of the section to be treated. Once the ideal quenching temperature is determined, the drawing or annealing temperature can be arrived at, depending upon the required hardness of the part. An absolutely uniform product can be obtained if such a practice is followed. In the case of the common grades of steel it is not necessary to work to such close ranges in the quenching temperature, but to obtain the maximum efficiency with the higher grades of special alloy steels for the more important parts, they should be given the best heat-treatment possible.

To illustrate the effect of variations in the quenching temperature, I selected nine bars of 0.45 per cent carbon simple steel and heated them to temperatures ranging from 1300 to 1800 deg. fahr. and quenched them in water. These bars were all annealed at a uniform temperature of 1175 deg. fahr. This grade of steel contains sufficient ferrite to permit a clear interpretation from its microstructure of the effect of varying quenching temperatures. Fig. 4 shows the average microstructure of these bars after the various quenching temperatures. It will be noted that the most nearly ideal structure was obtained in the bar quenched at 1500 deg. The bars quenched below this temperature did not retain all of the pearlite and ferrite in solid solution. The bars quenched at from 1550 to 1800 deg. are seen from their microstructures to have been quenched at excessive temperature. Therefore, with this grade of steel 1500 deg. is the best temperature at which to quench. The ideal quenching temperature can be readily detected upon cold-fracture, but as it is difficult to reproduce such fractures photographically, I selected the microphotographs to demonstrate the point.

Some years ago I was connected with a manufacturing company which had returned to it about 5000 important parts a year, parts which were the backbone of its product, due to their having failed in service on account of being too hard or too soft. The company bought steel within a 10-point carbon range, forged it into the parts and gave them all practically the same quenching and drawing temperature. Therefore, those which were on the low side of the carbon and manganese limits were too soft and those on the high side too hard. It then established the practice of forging four test-pieces 20 in. long and 2 in. in diameter from each heat received, giving some of these a standard heat-treatment by quenching in oil at about 1500 and annealing at about 1200 deg. fahr. Tensile tests were made with these bars and if the results showed that they were either too hard or too soft, the remaining pieces were heat-treated and the annealing temperature regulated accordingly. The correct annealing temperature was always ascertained in the second treatment. The parts then went through the forging and heat-treatment departments by heats which were identified by lot numbers, receiving the heat-treatment determined by the preliminary test-bars. After this practice was put into operation the firm did not have 100 failures per year.

As it is impossible for the steel manufacturer to duplicate a heat of steel of identically the same composition throughout, it is necessary that he be given certain ranges in carbon, manganese, nickel, chromium and the other elements. There are times when one or more of these elements are outside of the allowable ranges and in such cases it should be determined in the event that one hardening element, carbon, for example, is on or below the low limit, whether one or more of the elements, manganese, nickel, chromium or vanadium are on or above the upper limit, as many times it is possible that there are enough hardening elements on the high side to make up the deficiency of the element or elements on the low side, and such a heat will be just as suitable as if all the elements were within specified limits. The effect of the counterbalancing of the various elements in a heat of steel should always be taken into consideration. The important point to consider is whether the desired physical and service properties be obtained from the heat, not whether the heat comes within chemical requirements in every respect.

The essential thing in connection with automobile steels is their heat-treatment, and I wish to emphasize the fact that all the various parts produced from a given heat of steel should receive the treatment that is found to be best for that particular heat. The quenching bath must be near the heating furnace so that the temperature

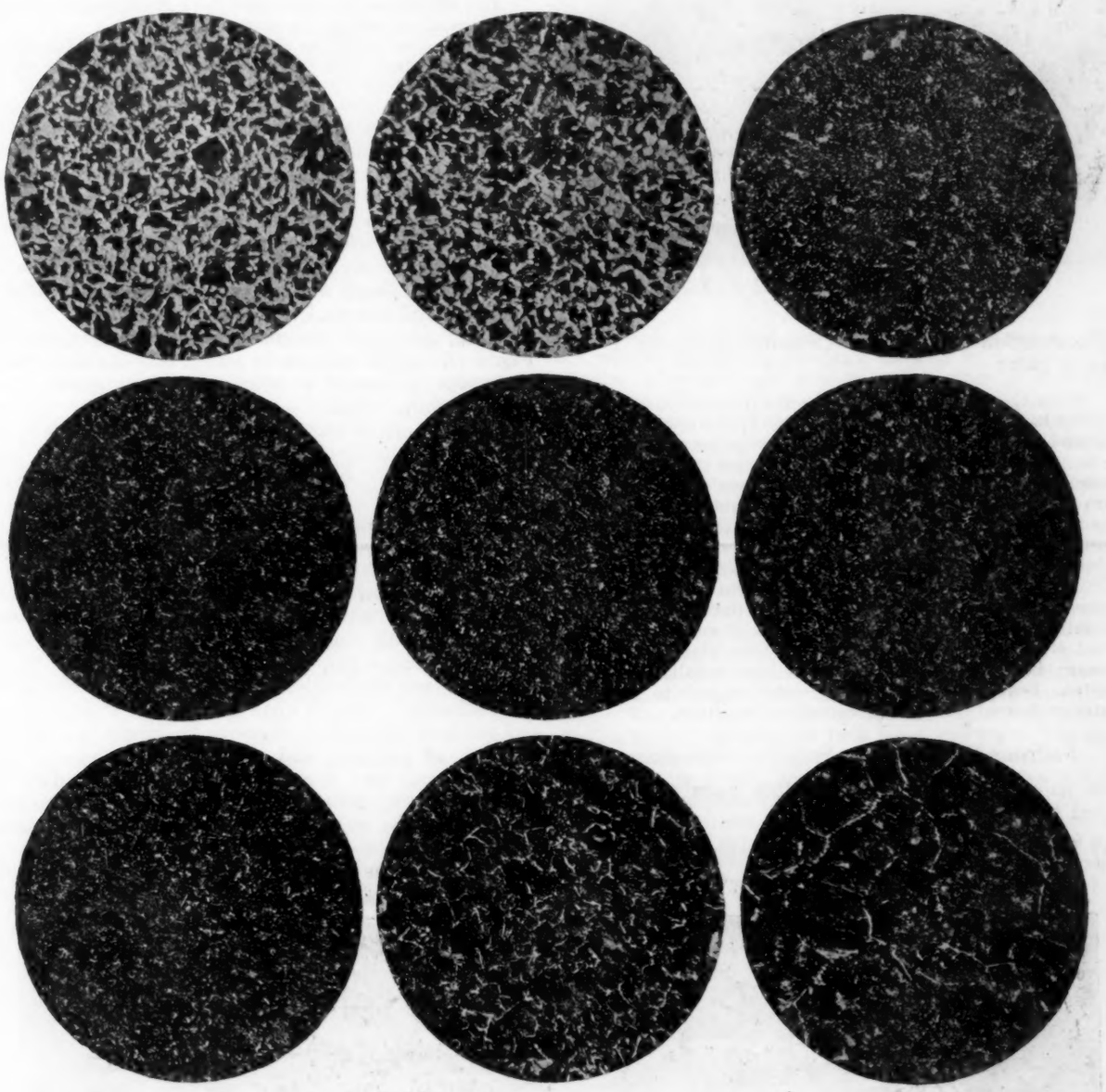


FIG. 4

The temperatures in degrees fahrenheit to which the various bars were heated prior to quenching are indicated below.

1300	1350	1400
1450	1500	1550
1600	1700	1800

will not be reduced in transit between the furnace and the bath.

CAUSES OF FAILURE IN SERVICE

The metallurgical defects which may cause failures are pipe and deep seams. Their cause can be readily determined upon an examination of a broken part. The percentage of failures on account of metallurgical defects is low as compared with those due to the use of grades of steel that do not have physical properties permitting of a high enough factor of safety; improper heat-treatment, excessive vibration and faulty design causing strains to be set up during heat-treatment. Moreover, many service failures are due to machining sharp corners instead of proper fillets in parts.

Failures in service which are due to excessive vibration, improper heat-treatment, the use of the wrong grade of steel and faulty design often show a peculiar wavy circular marking on the fracture, which is called a fatigue fracture or progressive break. Sometimes such fractures start at the outside surface and gradually increase in continued service until there is little metal holding the part together. At other times the nucleus of the break occurs inside of the part and progresses toward the outside. These internal fatigue breaks occur in parts the center of which is subjected to a combination of compression and tension. Two types of fatigue fracture are illustrated in Fig. 5. One of the best explanations of the development of a fatigue or progressive break has been made by James E. Howard, engineer physicist

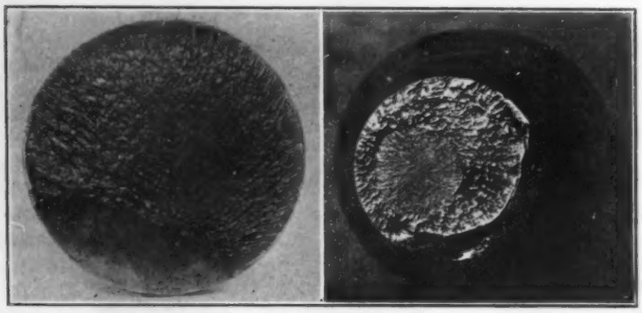


FIG. 5

of the Interstate Commerce Commission, which I will quote in part:

> When these progressive breaks are internal they generally have a nucleus having a silky appearance, sometimes called a tension spot. The surrounding parts have a bright silvery luster until the break has extended and reached the periphery of the part; then the surfaces are darkened. The silvery luster is doubtless acquired by the opposite surfaces hammering each other. The progressive development is shown by the concentric ripples on their silvery faces. The walls of an incipient fissure are separated a very minute distance, probably represented by the elastic resilience of the steel in that vicinity. The phenomenon of permanent set or permanent elongation of the steel cannot take place when a fissure is formed in a matrix of structurally sound metal. Seamy or spongy steel would appear to favor interior flow of limited degree without fracture.

FACTORS DETERMINING SOURCES OF SUPPLY

The points to consider in deciding upon the source of steel to be purchased are

(1) Is the steel manufacturer in a position to obtain raw material of good quality.

(2) What are the manufacturer's facilities for testing and inspecting his product

(3) Has he adequate chemical and physical laboratory equipment and an efficient organization in these departments

A prospective purchaser of large tonnages of high-grade steels should personally inspect the plant of the manufacturer and become acquainted with the manufacturer's organization. In this way he can generally form his own opinion as to the ability of the manufacturer to furnish him with the desired product.

Is the plant of the manufacturer clean? In a clean and orderly plant, steel is properly marked, piled and assorted, and the workmen are more efficient. If a plant is dirty, workmen become careless and mix-ups occur. Fig. 6 shows the manner in which billets should be piled and properly marked to keep the various grades of steel from becoming mixed.

The past performance of the manufacturer should be taken into consideration; in other words, what grades of material has he been accustomed to manufacture. The experimenter should be given an opportunity to demonstrate his ability to manufacture special steels, but the consumer should avoid ordering too large a tonnage from him until he has demonstrated what he can do.

Each automobile manufacturer should have in his organization a competent metallurgical engineer who is conversant with the mechanical design of the various parts and has a knowledge of the strains and stresses to which they are subjected in service. He should have full authority to decide upon the type of steel to be used and the heat-treatment necessary to impart the best combination of physical and service properties. Such an engineer can save a company thousands of dollars by reducing service failures. For parts subjected to steady low strains the automobile engineer will select one of the cheaper grades of steel of a composition that will have the necessary tensile strength, elastic limit, elonga-

FIG. 6

tion, etc., to withstand these strains. For parts subject in service to severe vibration and shocks he will select a high-grade alloy steel and pay particular attention to obtaining the very best properties possible from this steel by correct and careful heat-treatment.

There is one important commercial point that I think should be emphasized. The consumer in making his alloy-steel connections should, after determining upon proper sources of supply, retain these and not allow minor price fluctuations to affect him. Too often purchasers magnify the importance of saving a fraction of a cent per pound and contract with new sources of supply, which, however capable of making good steel, due to lack of knowledge of the individual plant's requirements, often cause increased shop and service losses which overbalance by far the price benefit.

A FRENCH TWELVE-CYLINDER CAR

LISTED at 75,000 francs for chassis with tires, the new twelve-cylinder Corona is apparently the most expensive car built in France. The technical expert is G. Michaux, who is well known in the French industry as a consulting engineer; some years ago he was responsible for the Peugeot racing creations.

The cylinders of the Corona are in two castings mounted at an angle of 40 deg., and have a 120-mm. bore and a stroke of 80 mm. The valves are in the head, and carried in cages. The camshafts are in the crankcase, the valves therefore being worked by push-rods and rockers. An aluminum cover hides both the valve-operating mechanism, and the plugs and wiring. The crankshaft is carried in three roller bearings, with a double-thrust ball-race at the flywheel end. The connecting-rods are tubular.

The oiling is special and unusual. The dry sump system is employed for the engine, with pressure feed to all bearings. The main supply of oil is carried in a dashboard tank, and from there is sent to the engine and back to the tank by the scavenging pump in the base chamber. The same oil is delivered to the gearbox, the rear axle, the spring-shackles and the steering-gear.

The gearbox, which provides three speeds ahead, is a unit construction with the engine, and has a centrally placed change-speed lever. The propeller-shaft is enclosed, and it is through this housing that oil is fed to the rear axle. This latter is full-floating type, and the differential casing with the driving pinion and the spiral-bevel gear can be lifted out without disturbing the axle housing or taking off the wheels. This makes it a very easy matter to adjust the pinion and the gear, or to change the gear ratio.

Ignition is by two magnetos. The carbureter is a double type for each set of six cylinders, this being equivalent to a separate carbureter for three cylinders, and cooling is by a turbine with a vertical axis running at one and a half times the engine speed. The water, after being sent from the front to the rear of the cylinder blocks, is brought back to the front end again around the exhaust manifolds. The fan is gear driven, and the cooling system is fitted with a thermometer.

The Corona is equipped with 16½-in. diameter front as well as rear-hub brakes, which operate together, but with a slight lead for the front-hub pair. Operation is by pedal or lever, or the two together. Roller bearings, with thrust ball bearings, are used for the wheel-hubs, which are interchangeable. The tire size is 895 by 130 mm. or 895 by 150 mm. Springing is semi-elliptical both front and rear. The equipment includes electric lighting and a starting motor.

The builder gives a five years' guarantee, which is applicable to any number of owners, on condition that the seals are not broken and that the car is examined by him each time it changes hands. After a car has covered 60,000 miles, the maker undertakes to inspect and overhaul it completely for the inclusive price of £200.—*Motor Trader* (London).

SAFETY IN LANDING AN IMPORTANT FACTOR

AFTER being in operation for nearly a century, neither railroads nor ocean steamers are immune from accidents, and it is probably useless to expect that travel by the air can be rendered more secure than these older methods by land and sea. But it is reasonable to hope that the frequency of accidents may be reduced, thus providing aviation with a relative security, at least equal to that of other methods of locomotion. The solution of the problem of safety in airplanes can be considered from two standpoints, namely, by improving the airplane itself and by the use of safety devices. For the public safety, and especially to give confidence to the passengers, it is necessary to study devices for absolutely avoiding fires and all danger of impact on landing. As a matter of fact, the landing chassis of the large airplanes have received little attention up to the present time. For the war planes, we have certain fixed rules, and landing chassis with V-struts, jointed axles and rubber shock-absorbers have been generally adopted. But with such devices, if the pilot makes an abrupt landing, the fuselage receives a considerable shaking up.

In 1911 and 1915 many were working on special devices, and the Voisin and the Breguet had heavy springs and oil shock-absorbers on the struts; but these landing chassis were found to be too heavy and hardly necessary for the military airplane. Tests have also been made with devices having shock-absorbers on the struts at the point where they join the fuselage, the rear strut being jointed. The advantage of this device is that its wheels have the tendency to go forward under the impetus of the shock, thus avoiding the danger of turning turtle. It has been assumed that the shocks are practically deadened in the following proportions: 30 per cent by the pneumatic tires; 15 per cent by the flexion of the non-jointed axles; and 55 per cent by the shock-absorbers.

For the war airplanes, nearly all the builders placed the center of the wheels in front of the center of gravity at a distance about equal to one-quarter of the height of the center of gravity from the ground, corresponding to about 13 or 14 deg. This gives a device which practically avoids the danger of overturning, but which in certain cases subjects the tail-skid to rather severe strains, especially if the fuselage is short. Several companies have studied out special landing chassis for their bombing airplanes, which have the wheels arranged in tandem with a common shock-absorber. This device gives a compensation between the two axles and appears to be fairly satisfactory. For the airplanes intended to carry heavy loads, the question of tail-skid shock-absorbers is an important one, as there is little use of easing the landing if, at the moment when the tail-skid touches the ground, all of the passengers are to be rudely jostled about in their seats.—Air Service News Letter.

Presentation of John Fritz Medal to Orville Wright

FOR the second time since the establishment of the John Fritz Medal, the Society has been honored by its award to one of the members. The medal which was established in honor of that pioneer of steel making, John Fritz of Bethlehem, Pa., is awarded not oftener than once a year for some noteworthy achievement in science or engineering. The first member to receive the medal was Thomas A. Edison in 1908, the award in this case being based upon the work which Mr. Edison had done in the development of electrical apparatus. The award this year to Orville Wright for achievement in the development of the airplane is a recognition of the part played by aeronautics in the civil and military life of the country of the present day and is also the first recognition by the board of award of the automotive industry.

The medal was presented in the auditorium of the Engineering Societies Building, New York City, on May 7. It is the custom in awarding the medal to have addresses delivered by engineers or public men who are associated with the industry that is honored. The speakers on this occasion were Major-General George O. Squier, U. S. A., chief signal officer, and Edward A. Deeds, president of the Domestic Engineering Co., Dayton, Ohio, and a former member of the Aircraft Production Board. In his remarks General Squier dwelt upon his relations with Mr. Wright in connection with the first flight and the early Government work in aeronautics, giving a brief but nevertheless interesting resume of the events which culminated in the first successful flight in a heavier-than-air machine on Sept. 9, 1907, and the subsequent work that was done to place airplane production for the Government on a commercial basis. In his address General Squier paid a glowing tribute to the perseverance of Mr. Wright and his methods of work. Mr. Deeds spoke more on what perhaps might be termed the personal side of Mr. Wright, tracing his achievements from the time, when as a boy, he and his brother built a printing press and published a newspaper, through the development of bicycles and miniature flying machines to the experiments that were conducted at Kitty Hawk, N. C., in 1899. The work which both brothers did at Kitty Hawk and also at Dayton following their early experiments in the development of controls, propellers and engines was also brought out by Mr. Deeds.

ADDRESS OF MAJOR-GENERAL SQUIER

THE proposition of the Government itself entering into a contract for a heavier-than-air flying machine was really a rather unusual one in the year 1906. Flying had not reached a stage in which governments were apt to take up the subject. In any case, in 1905 and 1906, the Wright brothers, having perfected their experiments at Kitty Hawk, N. C., took steps to bring their airplane to the attention of the Government. The Board of Ordnance and Fortifications, for the Army, took up the invention, examined it superficially, as far as the theory was concerned, and it fell to the office of the Signal Corps of the Army to purchase the airplane because the Board of Ordnance and Fortifications recommends, but does not purchase. The Signal Corps had at that time a fund with which to buy war balloons.

My connection with the matter was more or less accidental. I remember very distinctly my first meeting with the Wright brothers. They came into the office, and the conversation turned on the airplane; and since it was my duty, or the duty of the office, rather, to prepare specifications for this machine, not knowing what was required and not having very much confidence in the airplane, I wisely asked, "What can you do?" We got the specifications practically from the Wright brothers. All I wanted to be sure about was that there should be no gas bag connected with it. Those specifications, which were issued in 1906, were probably the first that any state or government ever issued to purchase a flying machine; and we have the credit today of having embarked on that plan.

When it was decided to buy one of the machines, the specification required certain simple things, that the operator should go in the air and stay an hour without alighting. It did not make any difference what he did in that hour, but he was not to alight. It did not make any difference what kind of engine he had, or anything else. One of the conditions was that the operator had to make a flight of 5 miles and return, with and against the wind. He had to carry an extra man, the two weighing not less than 250 lb., and a certain amount of fuel, and so on, for a minimum flight. That was about all there was to the specification except that 36 miles had to be made in speed, I think. We fixed a sliding scale, so that for every mile more than 36 they made they were to get a bonus. This made it possible for them to receive with bonus $30,000, I think. The flat price was $25,000.

The Beginning of Flying

The specification was issued in December, 1906, as I recall; and in the following year the Wright brothers reported, according to the specification, at Fort Myer, Va. Then the interest in airplanes began in earnest, so far as the world is concerned. During the first few days there was naturally much tuning up, care and tediousness. The flights were made in the afternoons, as I recall, between four and six, because the air was best at that time. This went on for some time. Suddenly on the morning of Sept. 9, 1907, I was called up at about half-past eight in the morning at my office and told that Orville Wright had flown for 52 min. Up to that time the flights had been for short periods. That morning settled it. On the afternoon of the same day Mr. Wright flew for over an hour, and also carried a passenger for a brief time. I think that Sept. 9 was probably the greatest day in aeronautics, the day the world realized that the flying machine had arrived.

In those days the slightest little stirring breeze prevented flight. I can see Wilbur Wright holding his handkerchief up every little while in the wind to see whether they could fly. A few days later Mr. Wright had his unfortunate fall, which delayed the completion of the tests until the next year. In 1908 every condition in the specification was fulfilled by Orville Wright. He had started

this particular job and was to finish it. Wilbur could have finished it, no doubt, at any time. But it was characteristic of the brothers that that job, which had been especially assigned to Orville, had to wait until he got well.

The Specifications Met

It was on July 28, 1908, I think, that all known records were broken at once, the altitude record of 200 ft., the cross-country record with a passenger, the speed record and the climbing record. A flight of 5 miles to Shooter's Mill and back, with and against the wind, was made. We did not know it then, but to fly at 150 or 200-ft. altitude over that course was very dangerous. There was not a place on it where a landing could be made except on the tops of trees. Even today flying at that altitude is dangerous. Due to our ignorance the Government prescribed that height. We wanted to make the flight as difficult as possible. The airplane was subsequently placed in the Smithsonian Institution, where future generations can see it. The Government, always mindful of recognizing genius and accomplishment, passed certain resolutions of thanks to the Wright brothers. A medal was struck for them.

Personality of Orville Wright

It has been a great privilege to me to see the methods of work and the qualities which made the Wright brothers so successful. In the first place, they were very reticent. I used to have great trouble to get them to say anything on any subject. Of course, the experiments at Fort Myer brought newspaper people there from all over the world. We had to build tents for them, and to build telegraph offices. They had to camp out there, and as they were all paid people, they had to get some copy for their journals after each flight; and the only way to prevent one paper from getting a beat over another was to get Mr. Wright, after he had come down, in the middle of them all and say, "Go ahead with your questions." We were sure in that way that no newspaper would get exclusive information. The Government had to be particularly careful to treat everybody alike. The Wright brothers never said anything in those days. They were very busy doing things.

We never could get them to go to any dinners. Of course, everybody wanted to entertain them, but they seemed to have the power of shutting off the past and the future, and doing the day's work as though that was the only thing in the world. They had powers of concentration, allowing nothing to disturb them, going straight ahead, that should be emulated by every man who hopes to do anything.

It was remarkable to see them work. You never saw many books about. I recall the discussions that we had every day. They would automatically take opposite sides. It did not really make any difference what they actually thought about a subject; they took opposite sides anyway. When they finished talking over a matter under discussion, they had some new data to digest. They proceeded that way day by day; after the discussion was through there was not much left to be surmised about a given point. They worked naturally together as a team.

This is undoubtedly the greatest engineering age the world has ever seen. As we look out over this great city, how much of it is engineering in some form or other! I believe that this country is equal in engineering invention to any in the world. The significance of this meeting, to confer the John Fritz medal on an engineer who is, I think I am safe in saying, as we consider the measure of what he did, and what it may do for this world in the years to come, the most distinguished engineer in the world today, is very great.

ADDRESS OF EDWARD A. DEEDS

THE Wright brothers were always of an inventive turn of mind. They printed a little newspaper in Dayton. Orville started it first, and Wilbur came along and helped him. They built their own printing press. Everything they did they did with their own hands, developing their own things.

Later they went seriously into the bicycle business. They built their own machine from the ground up. It was used by racing drivers all through the Middle West.

Beginning of the Flying Machine

Their first thought of the flying machine dates back to the time when their father brought home a helicopter that would fly to the ceiling. The boys were much interested. They built larger and better helicopters. They made some so large that they would not fly.

They went into kite-flying and became great experts. Then they interested themselves in flight in a bigger way. The two boys always worked together. They were inseparable in play also.

Their inspiration came from Lilienthal and Mouillard. The French writer, not so skilful, did not know so much about aeronautics, but wrote most beautifully about it. Lilienthal had gone further. He was a charming writer, and possessed not only a vivid personality but was practical. Two schools of flying had grown up; one was for soaring without the aid of power, and the other advocated the use of mechanical power. The Wright brothers built a glider in 1900. They needed, of course, for gliding some place where the wind blew, so that they could glide into it. They wrote to the Weather Bureau to find out where the greatest wind was in this country, and were told, "Down at Kitty Hawk."

Experiments at Kitty Hawk

They had all the technical data on the subject they could get from books. They had gone into the matter primarily for sport. Their glider did not work out according to the books. They took the subject up with Chanute, who was a good friend of theirs; he recommended that they follow closely the tables given by the different authorities.

The following year, 1901, they went down to Kitty Hawk again with a glider built according to the views of the latest authorities. It did not work nearly as well as the one they had made the year before. They had no end of difficulty at that time.

When they went home to spend the winter, they built a little wind tunnel and developed an apparatus for measuring surfaces, which had an automatic balance and canceled out the errors. When they did that they made the real step forward. They made a large number of measurements. Thousands of little models were made to find out the real facts about the surfaces. To their astonishment, and the astonishment of everyone else, they found that various statements that had been printed theretofore were erroneous. The next contribution they made was the development of a system of control, so that when they were able to glide they could control the machine, steer it, and make it do what they wanted it to do.

The Wright brothers were wise in not attempting to

install mechanical power in their machine before the other problems involved had been worked out. The propeller was a serious problem. Their first propellers gave an efficiency of 66 per cent, which was remarkable, and made flight possible.

Then the only thing they needed was the engine, and they wrote to different manufacturers to try to get one. They finally had to build their own engine.

The First Airplane

They installed two propellers running in opposite directions. Frequently something would break and they would have to go back to Dayton to get new shafts and the like. The propellers would not stay on the shafts, the nuts working loose. Being in the bicycle business, they remembered the cement for solid tires, and used it for holding the nuts on.

They overcame difficulties one after another. Winter and snow came before they were ready to try a flight; and on Dec. 14, 1903 they made the first attempt. They had been waiting for the wind to be right. It was not just right, but they wanted to fly anyhow. They took themselves and the machine up on the side of a hill and started the engine. The machine got away, and went over on its side and snapped one wing tip, and they did not get anything out of that first attempt.

It took two or three days to make necessary repairs. Having to wait for the weather to get better, the next flight was on the 17th. It was Orville's turn, and for that reason he made the first flight that was ever made. The man whom we honor tonight was the first man in the world to leave the ground in a machine propelled by its own power and maintain a flight and land on ground not lower than that from which the machine started.

The flight was of only 12 sec. duration. This seems like a short time; but he covered the equivalent of 540 ft., including the speed of the air. The next flight, of 59 sec., was made by Wilbur, in which he covered 850 ft. They were having a glorious time talking about what had been done when a gust of wind came along and flopped the machine over and wrecked it. But flying had become a matter of history.

Flying Abroad

The Wright brothers went to France and Germany in 1907. Wilbur flew in France in 1908 and won the 30-meter altitude test there. He won a 100-meter test, getting up 300 ft. Orville flew in Germany, climbing 2000 ft. and winning all the prizes.

Orville Wright is as much interested and as accurate in his work as ever. During the war he took an active part in aeronautics. The De Haviland plane was modified to receive the Liberty engine under his direction.

AERONAUTIC DIVISION REPORT

At the Aeronautic Meeting of the Society held in New York City on March 10, H. M. Crane, chairman of the Aeronautic Division of the Standards Committee, presented a report covering the activities of the Division. The report, substantially in full, is given below.

As many of you know, during the war there was a very great legitimate pressure toward standardization. Standardization was highly important for industrial and military reasons and much was done, and more was attempted, with results which were good in very many cases, and in others doubtful. For the year since the war closed, the whole matter has lain dormant. It is now being actively taken up again, with a committee which is a very strong one and representative of the whole industry. The industry being small, it is possible to have on the Standards Committee representation of almost everyone interested.

The first thing that the Aeronautic Division will do is to go over what has been done in the past, and see what, by experience, has proved to be useful, and what is now open to question. The questionable points will be studied again in detail, and in addition the new points that have been suggested in the last year will be taken up. It is the intention to take up with everyone in the industry the results of past standardization, by sending a questionnaire. All will be asked how far standardization has been useful to them. I cannot urge too strongly that those who receive this questionnaire, give it earnest and prompt attention, because standardization is of value only insofar as it is used. If the standards appear useful, we would like to know that; if there is a reason why any of them seem foolish, or if they seem to indicate that we are going too far or too fast in the new industry, we would like to know that, also. In other words, we want from the men who receive the questionnaire a frank and full statement of how they feel about the matter. I want to assure them that they will not be able to hurt our feelings by any suggestions or criticisms they may offer.

The committee's theory of standardization is based in part on the belief that a standard that is not used is an actual weakness; that the strength of standardization is in the standards that are in daily use, and that the strongest standards are those that have become standardized by themselves, and not by the work of the committee, such as the spark-plug shell, which was standardized with 12-mm. length and 18-mm. diameter of thread, long before the committee took up its work. The committee even considered changing the length of the thread, but it was too late.

I think I need not go into that any further, but I will ask you again to help the committee all you can by suggestions, and further, by at least attempting to use in new work such standards as have been recommended. If, after attempting to use them, you find that they are a handicap, or should not be used, we would like to have you tell us so, in order that the respective matters can be given the further consideration they deserve to secure a practical workable standard.

AIRCRAFT POLICY OF THE ARMY AND THE NAVY

In a general order recently issued by the War Department the policy of the Army and the Navy relating to aircraft as approved by the Aeronautical Board and the secretaries of War and Navy is given. Aircraft to be used in the operations of war will be designated as (*a*) Army aircraft, (*b*) Navy aircraft and (*c*) Marine aircraft.

The first class will be provided by the War Department and manned by Army personnel. The Navy Department will supply both the aircraft of the second group and the necessary personnel as well as furnishing the aircraft for the third group. This last will, however, be manned by personnel supplied by the Marine Corps.—Air Service News Letter.

Alcogas as Aviation Fuel Compared with Export Grade Gasoline[1]

MIXTURES of gasoline and alcohol, when used in internal-combustion engines designed for gasoline, have been found to possess the advantage of alcohol in withstanding high compression without producing "knock" while retaining the advantages of gasoline with regard to starting characteristics. Tests of such fuels for maximum power-producing ability and fuel economy, at various rates of consumption, are thus of practical importance with especial reference to high-compression engine development. Aviation Alcogas, prepared by an industrial firm at Baltimore, was submitted for test by the Bureau of Standards, through the Navy Department. It is apparently a mixture of about 40 per cent alcohol, 35 per cent gasoline, 17 per cent benzol and 8 per cent other ingredients. It is not the Alcogas prepared for commercial or passenger-car use. Its exact composition and methods of manufacture are a trade secret.

The tests consisted in a direct comparison between Alcogas and standard, export grade, aviation gasoline, in a twelve-cylinder Liberty engine, with respect to the maximum power attainable and fuel consumption with the leanest mixture giving maximum power. They were made in the altitude laboratory of the Bureau of Standards, where controlled conditions simulate those of any altitude up to 30,000 ft. The speed range was 1400 to 1800 r.p.m.; the altitude range, ground level to 25,000 ft. One series of comparisons was with 5.6 and the other with 7.2 compression-ratio pistons. At 900 r.p.m., the actual compression pressure with the 5.6 compression

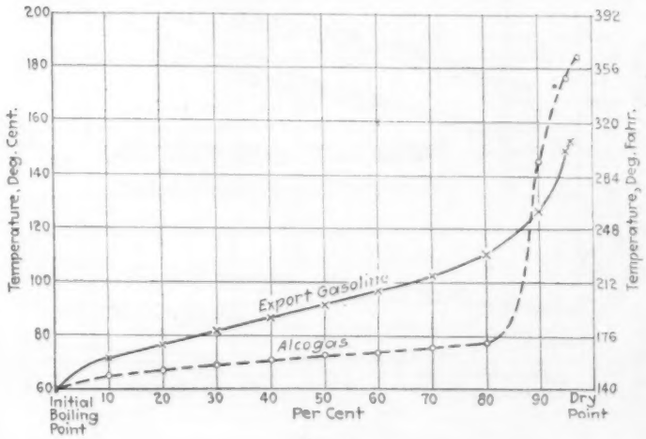


FIG. 1

ratio was about 125 lb. per sq. in. and with the 7.2 compression ratio about 170 lb. per sq. in.

The physical properties of the two fuels used are given in the accompanying table and Fig. 1. The gasoline conforms to specification No. 3512, Bureau of Aircraft Production, 1918, for export aviation gasoline.

[1]From an abstract of Report No. 89 of the National Advisory Committee for Aeronautics, Washington, supplemented by diagrams from Automotive Powerplants Report No. 68.

DISTILLATION AND OTHER PROPERTIES.

	Aviation Alcogas	Export Aviation Gasoline
Total heating value		
B.t.u. per lb.	15,910	20,340
Calories per gram.	8,840	11,300
Appearance	Clear lavender	Clear water white
Odor	Alcohol and ether	Gasoline
Specific gravity at 15.6 deg. cent.	0.799	0.710
Distillation (Temperatures in deg. cent.)		
Initial boiling point,	60	59
10 per cent	65	72
20 per cent	67	77
30 per cent	69	82
40 per cent	71	87
50 per cent	73	92
60 per cent	74	97
70 per cent	76	103
80 per cent	78	111
90 per cent	145	127
95 per cent	177	150
Dry point[2]	184	153
Residue, per cent	1.00	1.50
Loss, per cent	2.00	2.50
Gum, per cent	0.02	....
Reaction to litmus	Slightly acid	....
Corrosion	Black deposit	....

[2]97 per cent distillation for alcogas and 96 per cent for gasoline.

METHOD OF TESTING

The engine was started on one of the fuels and the air, load, speed, oil, jacket and other conditions adjusted. Starting with a mixture known to be rich, the fuel supply was reduced gradually and the maximum torque noted, the mixture being continuously made leaner until the torque was appreciably below its maximum value. The fuel flow was then increased enough to obtain the maximum torque again. The engine throttles were wide-open.

When the conditions were as desired, observations were made of the speed, load, various pressures, temperatures and quantities; the time required to use a certain weight of the fuel was noted. At the end of the run on one of the fuels, the valves were turned so as to supply the other fuel. After sufficient time had elapsed to make certain that none of the previous fuel remained in the line unused, the carbureter was again adjusted for maximum torque with minimum fuel, as already described. In this manner there was very little chance for any change in engine conditions to enter into the comparative results from the two fuels.

After the tests with the ordinary 5.6 compression ratio, the engine was taken down and overhauled; some parts were replaced, the 7.2 compression-ratio pistons were installed and the engine was thoroughly cleaned. This had no influence upon the comparison of the two fuels with either one of the compression ratios, all such comparative runs being made as mentioned and engine changes being thus eliminated. The overhaul may affect to some slight degree other comparisons, such as engine performance under different compression ratios, and deductions made from such data are not as accurate as in tests conducted with primary attention to constancy of

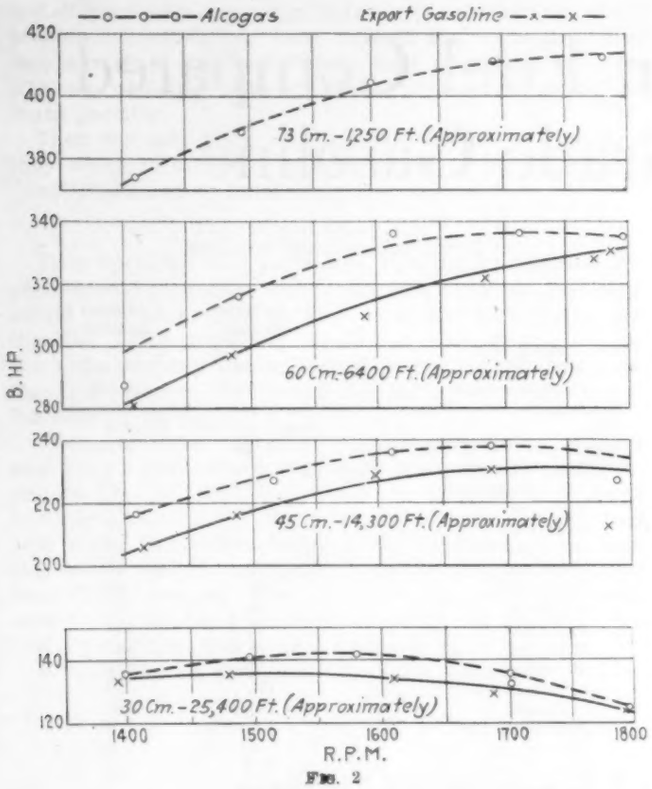


FIG. 2

engine conditions. This should be borne in mind when referring to Figs. 10 and 11. Figs. 2 to 5 show the test results based upon the 5.6 compression ratio, Figs.

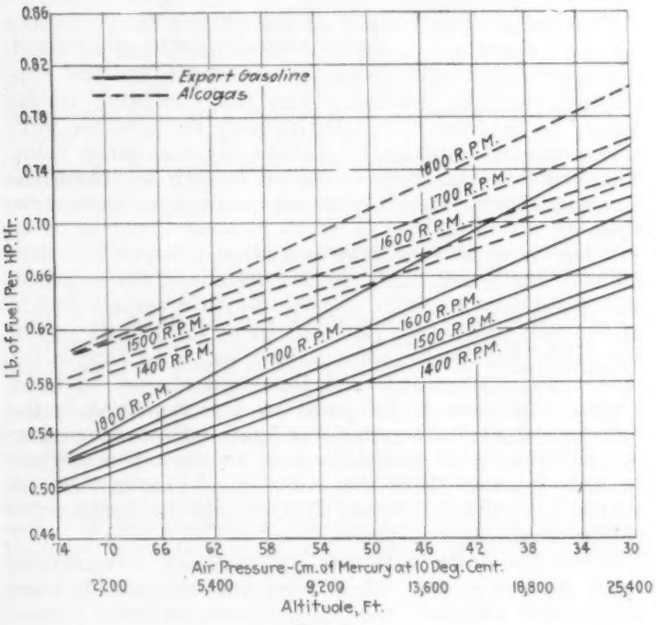


FIG. 3

6 to 9 those based upon the 7.2 compression ratio, and Figs. 10 to 12 furnish a comparison of engine performance with the different compression ratios.

It should be noted in connection with Figs. 4 and 8, the heat balance, that the rather marked reverse curvature of the curve showing the percentage of heat in the exhaust is undoubtedly a real reversal with altitude, and not an accidental coincidence of some undetermined cause which depresses or raises values. This conclusion is partly from the results of other tests with different fuels where, in numerous instances, evidence has appeared

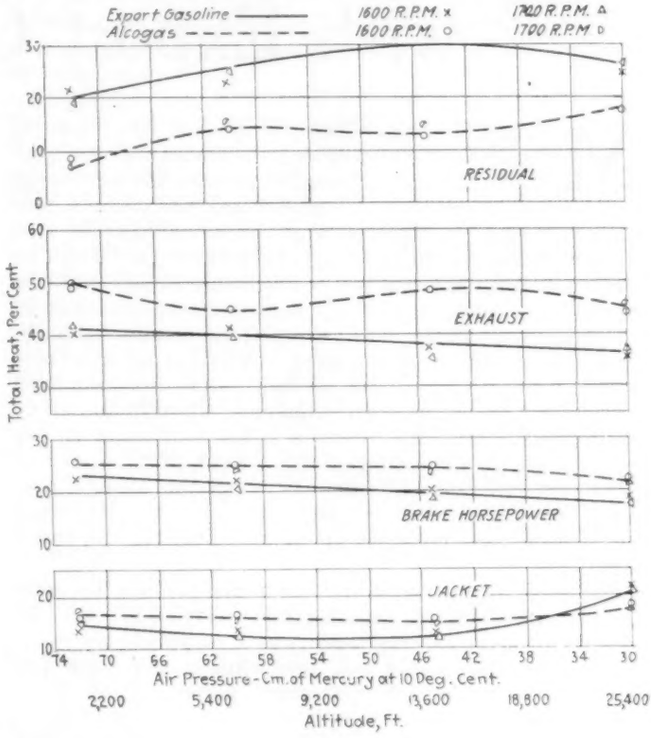


FIG. 4

that the most complete combustion of fuel is secured at conditions corresponding to altitudes of 10,000 to 15,000 ft.

Regarding the brake horsepower, Figs. 5 and 9, Alco-

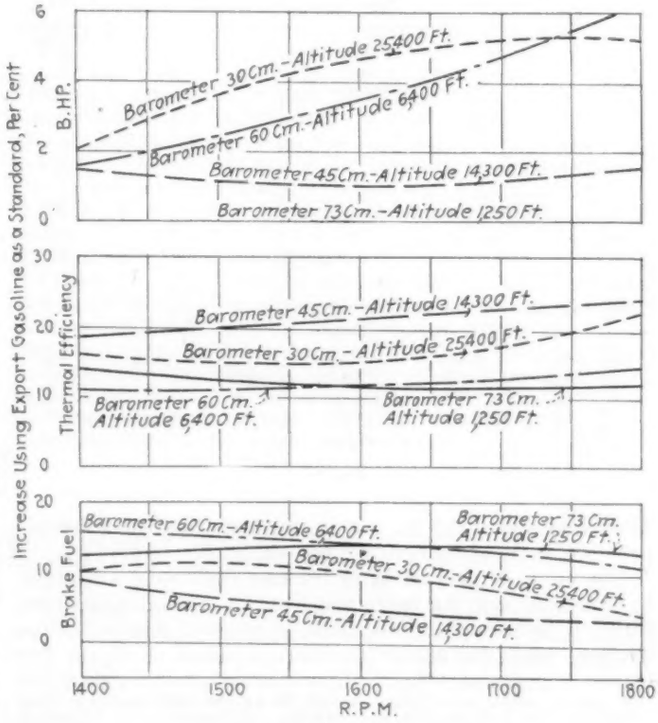


FIG. 5

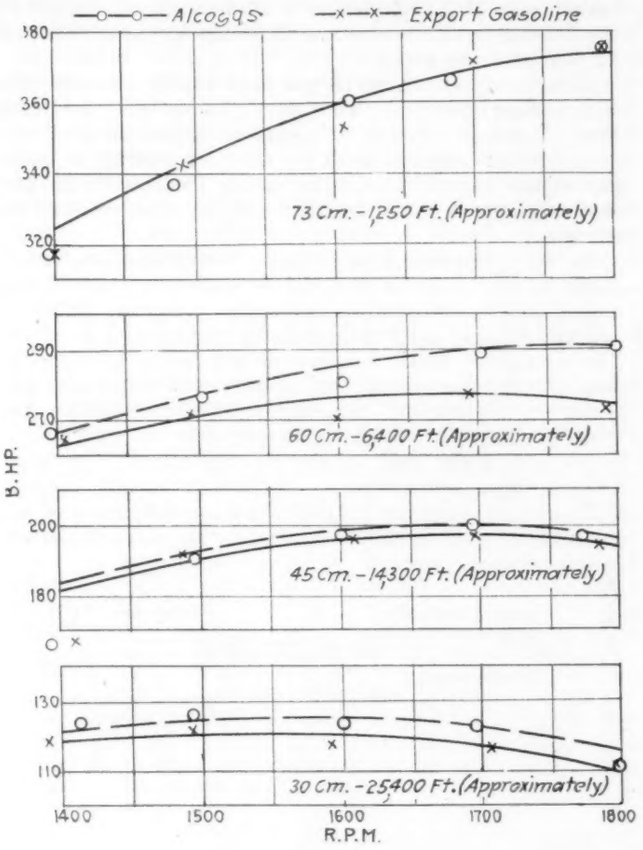


FIG. 6

gas shows a better maximum power-producing ability than export aviation gasoline at all speeds and altitudes except at ground level, the maximum difference being 6 per cent. At ground level the two fuels gave the same

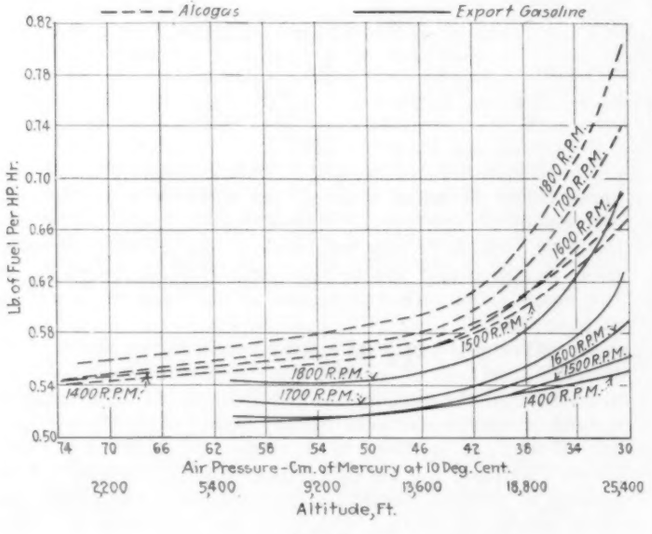


FIG. 7

result with the 5.6 compression ratio; the comparison was omitted with the 7.2 compression ratio because of the tendency of gasoline to knock at such high compression. The most common difference, omitting the extremely high and low speeds and considering all altitudes, is about 4 per cent, the superiority in brake horsepower of Alcogas over export aviation gasoline.

The gain in power-producing ability for Alcogas is at

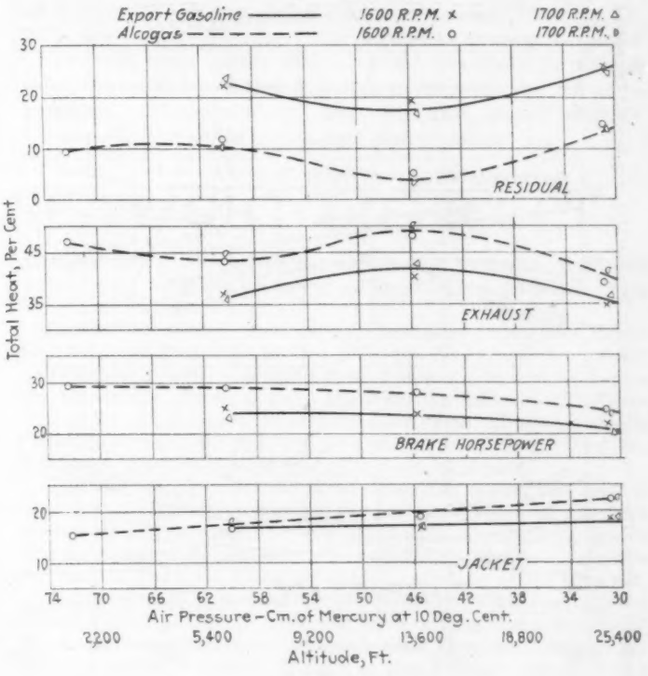


FIG. 8

the expense of a considerable increase in fuel consumption. Fig. 9 shows differences reaching 20 per cent. The general average of the excess consumption per brake

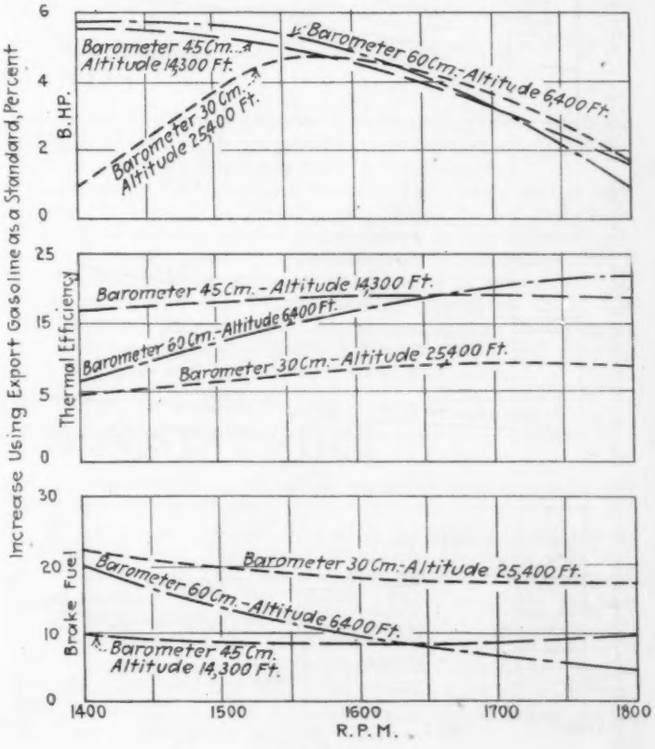

Barometer 45 Cm. - Altitude 14,300 Ft.
Barometer 60 Cm. - Altitude 6,400 Ft.
Barometer 30 Cm. - Altitude 25,400 Ft.
B. HP.
Thermal Efficiency
Increase Using Export Gasoline as a Standard, Percent
Brake Fuel
R.P.M.

FIG. 9

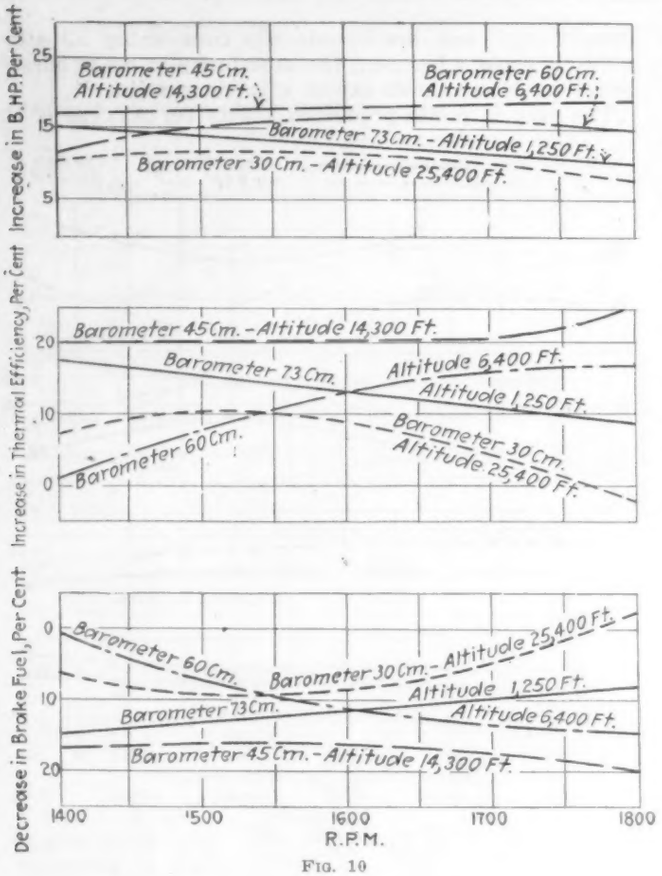

Increase in B.HP. Per Cent
Barometer 45 Cm. Altitude 14,300 Ft.
Barometer 60 Cm. Altitude 6,400 Ft.
Barometer 73 Cm. - Altitude 1,250 Ft.
Barometer 30 Cm. - Altitude 25,400 Ft.
Increase in Thermal Efficiency, Per Cent
Barometer 45 Cm. - Altitude 14,300 Ft.
Barometer 73 Cm.
Altitude 6,400 Ft.
Altitude 1,250 Ft.
Barometer 60 Cm.
Barometer 30 Cm. Altitude 25,400 Ft.
Decrease in Brake Fuel, Per Cent
Barometer 60 Cm.
Barometer 30 Cm. - Altitude 25,400 Ft.
Altitude 1,250 Ft.
Barometer 73 Cm.
Altitude 6,400 Ft.
Barometer 45 Cm. - Altitude 14,300 Ft.
R.P.M.

Fig. 10

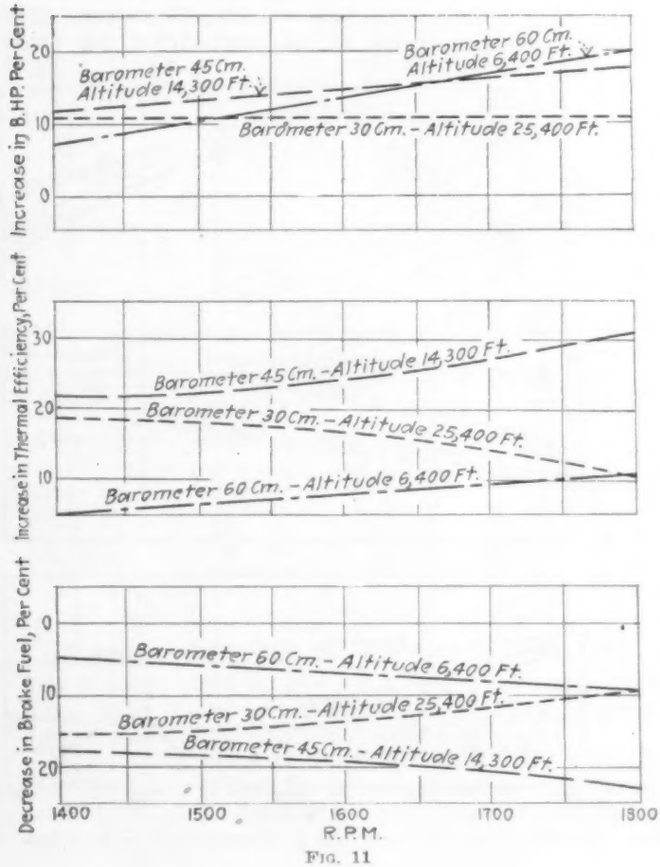

Increase in B.HP. Per Cent
Barometer 45 Cm. Altitude 14,300 Ft.
Barometer 60 Cm. Altitude 6,400 Ft.
Bardmeter 30 Cm. - Altitude 25,400 Ft.
Increase in Thermal Efficiency, Per Cent
Barometer 45 Cm. - Altitude 14,300 Ft.
Barometer 30 Cm. - Altitude 25,400 Ft.
Barometer 60 Cm. - Altitude 6,400 Ft.
Decrease in Brake Fuel, Per Cent
Barometer 60 Cm. - Altitude 6,400 Ft.
Barometer 30 Cm. - Altitude 25,400 Ft.
Barometer 45 Cm. - Altitude 14,300 Ft.
R.P.M.

Fig. 11

horsepower of Alcogas exceeds 10 per cent by weight at the 5.6 compression ratio and is nearly 15 per cent at the 7.2 compression ratio.

Alcogas shows about 15 per cent higher thermal efficiency than gasoline. This is a general average from Figs. 5 and 9. Stated in terms of brake thermal efficiency of an engine, the 15 per cent superiority of Alcogas means that if an engine using gasoline is 25 per cent efficient, it would be 28 to 29 per cent efficient on Alcogas.

As to comparisons by volume, when comparison is made on the basis of the pint or gallon instead of the pound, all of the data so far stated are very different because Alcogas is 12 per cent more dense than gasoline. The maximum brake horsepower attainable is independent of this unit, so that Alcogas is still 4 per cent superior in this respect. The excess fuel consumption per brake horsepower of 10 to 15 per cent of weight becomes practically zero on the volume basis. The total heating value per gallon of Alcogas is about 106,000 B.t.u. and of gasoline 120,000 B.t.u., a difference of 12 per cent referred to gasoline as a base, in place of 22 per

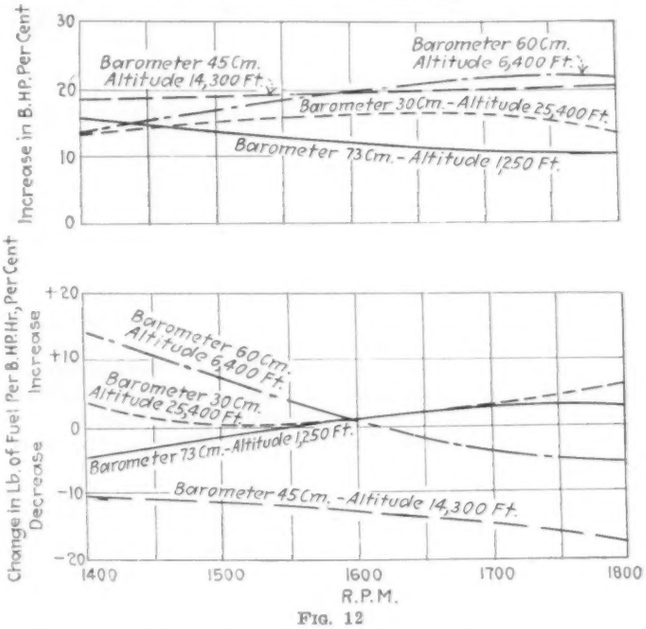

Increase in B.HP. Per Cent
Barometer 45 Cm. Altitude 14,300 Ft.
Barometer 60 Cm. Altitude 6,400 Ft.
Barometer 30 Cm. - Altitude 25,400 Ft.
Barometer 73 Cm. - Altitude 1250 Ft.
Change in Lb. of Fuel Per B.HP.Hr., Per Cent
Increase
Decrease
Barometer 60 Cm. Altitude 6,400 Ft.
Barometer 30 Cm. Altitude 25,400 Ft.
Barometer 73 Cm. - Altitude 1,250 Ft.
Barometer 45 Cm. - Altitude 14,300 Ft.
R.P.M.

Fig. 12

cent difference as by weight. This is seen to be of the same order of magnitude as the difference in thermal efficiencies of the fuels. The effective useful work obtainable, which is the product of the British thermal units supplied and the thermal efficiency, is found to be the same from either a gallon of Alcogas or a gallon of gasoline.

In reference to general engine performance there is no tangible method of comparing the smoothness of operation, but the testing staff felt that Alcogas gave a smoother running engine at all times. After continued use of Alcogas, no tests were made to determine the engine's condition but no evil effects were evidenced. The change in the compression ratio apparently has about the same effect, no matter which of the two fuels is used, until the temperature and pressure conditions are such as to cause poor engine operation with gasoline. The main advantage of Alcogas seems to be that it is known to be free from a tendency to knock at ground level when using the 7.2 compression ratio with wide-open throttle.

The numerical values for the effect of changing the

compression ratio, Figs. 10, 11 and 12, are subject to an undetermined uncertainty because of the overhauling of the engine between the two compression runs, but this uncertainty probably is small and the increase of brake horsepower at the 7.2 compression ratio over that at 5.6 compression averages at least 10 per cent for all speeds and altitudes. The fuel economy for maximum power is improved, so that the fuel consumption per brake horsepower and the thermal efficiency are at least 10 per cent better with the higher compression. This is the increase in "air standard efficiency," based upon an ideal engine following the Otto cycle, that results in a change in compression ratio from 5.6 to 7.2. Since a 7.2 compression ratio generally is considered too high for gasoline fuel, the engine performance with Alcogas at this compression ratio is compared with its performance with export aviation gasoline at the 5.6 compression ratio, in Fig. 12. This shows that Alcogas gives a general average of about 15 per cent more power with 7.2 compression-ratio pistons than the export aviation gasoline gives with the 5.6 compression. The pounds of fuel per unit power slightly favors Alcogas with the higher compression.

TRANSPACIFIC AIRPLANE FLIGHT DIFFICULT

THE shortest route possible to fly across the Pacific Ocean would be somewhat similar to the great circle route, but would cut the Aleutian Islands, passing north of the center of the group and through the Unimak pass at Unalaska. Presuming that the aviator flies from Victoria to Sitka, thence westerly to Unimak pass, in the Aleutian group, following the shortest possible route to Yokohama, he would have to travel only some 3500 to 3700 nautical miles. Of the two routes suggested for the Northern passage, and not dealing with the southern route via Hawaii, the great circle route would appear to be the best for aircraft work. The only land that could be made to coincide with a short aerial route across the Pacific is the Aleutian group of islands.

If the voyage by air was merely a matter of getting above the prevailing and fluctuating weather conditions on the surface, it would probably be simple to construct a machine that would give the requisite speed and flying endurance to accomplish the trip. Unfortunately, in this experimental stage of knowledge of the upper strata of air, it is impossible to say what conditions would be met with say at 20,000 ft. above the steamship route from Victoria to Yokohama. The fogs vary as to the height to which they extend, sometimes only the hull of the vessel being obscured and at other times the fog takes on the form of a cloud bank extending apparently several thousand feet into the air. There are no data at hand as to how high these fogs cloud the air. From December to February the fogs are not so much in evidence, and that period may be taken as being of fairly good visibility from the airman's viewpoint.

Gales are stated as coming, broadly, from two main sources, and operating in two different directions. A strong southeasterly wind operating from the southern end of Japan up across the Pacific toward the Aleutian Islands. The second class of hurricane is said to blow from off the southern American coast up the coast in a northwesterly direction. Cyclones are experienced near the coast of Japan.

The use of the directional wireless for aerial navigation has been in operation during the last two years of the war in the air. By it the R-34 kept a strict watch on its course in the transatlantic flight and an operator can get the bearings of various known sending stations in relation to the aircraft, it being then a matter of simple plotting. The operator on board a transpacific aircraft will have to take "back bearings" from the Canadian and American coast line, until within receiving radius of Dutch Harbor, in the Aleutian group, flying by back bearings again until within radius of the stations on the Japanese coast. Outside of these land stations, the operator must get in touch with ocean traffic. From any point of view, it will be the most difficult feat ever attempted by aircraft, and the men who succeed in crossing the Pacific by air will indeed have won the highest place in aeronautical annals.—Air Service News Letter.

GOOD ROADS

LAST year's Post Office appropriation bill carried a rider appropriating $200,000,000 of the Federal funds for road construction throughout the several States. This year the Post Office appropriation bill became law without any provision for highway legislation. This was because it had not been seriously urged that increased appropriations or further legislation extending federal aid should be included. Discontent exists among legislators because they are not pleased with the way that Federal money is being expended in highway construction. This is largely due to conditions in the States where the Federal aid money is divided among counties in the same way the Government apportions it to the State, that is, according to population, territory and road mileage. Short roads scattered over a State result instead of complete through highways built for permanency.

Connecting road systems between the States and a provision for permanent maintenance should be insisted upon. A national system, built and maintained by the Federal Government for the good of the whole country and built on such a basis that it will inspire the States to build good road systems connecting the Federal roads, is argued for. The Townsend bill proposes that the national system of highways shall be composed of two roads in each State, one running east and west and one running north and south.

MARCH OIL PRODUCTION STATISTICS

MARCH oil statistics, as compiled by Geological Survey, show an increased output of crude petroleum in practically every State. The total increase in the output of the United States wells in March as compared with March, 1919, is in excess of 6,000,000 bbl. The statement issued by the Survey says that this increased flow from our own wells was not enough, and 6,500,000 bbl. had to be imported from Mexico. Even with this increase available, after allowing for increased exports to Canada, there had to be severe drafts made upon the stocks of crude oil held by the pipe line companies, so that another 1,000,000 bbl. of stored domestic oil was contributed to the current consumption. The March consumption of crude petroleum exceeded that of a year ago by nearly 12,000,000 bbl.

The latest figures on the world's oil supply given out by the Survey show that foreign countries are using only half as much petroleum as the United States, but have seven times as much oil in the ground. These countries are now using about 200,000,000 bbl. of oil yearly, but they have resources large enough to last over 250 years at this rate of consumption. In striking contrast are production figures for the United States which at present rate of more than 400,000,000 bbl. a year has only an eighteen years' supply provided consumption does not increase.

Some Factors of Engine Performance

By V. R. GAGE[1] (*Non-Member*)

MID-WEST SECTION PAPER *Illustrated with* CHARTS

THE analysis of the engine tests discussed in this paper is now in progress at the Bureau of Standards, being conducted under the direction of the Powerplants Committee of the National Advisory Committee for Aeronautics. The complete analysis will appear as a report of the National Advisory Committee for Aeronautics. A large number of tests were made in the altitude laboratory, using aircraft engines. Many of these engines were of the same make, differing in compression ratio or dimensions. The testing program included determinations of the brake horsepower at various speeds and altitudes, or air densities, and the friction power, or the power required to operate the engine with no fuel or ignition at various speeds and air densities, with normal operating conditions of oil, water, etc. Some tests have included special variations, such as determinating the effect of variation of mixture ratio, air temperature and different oils.

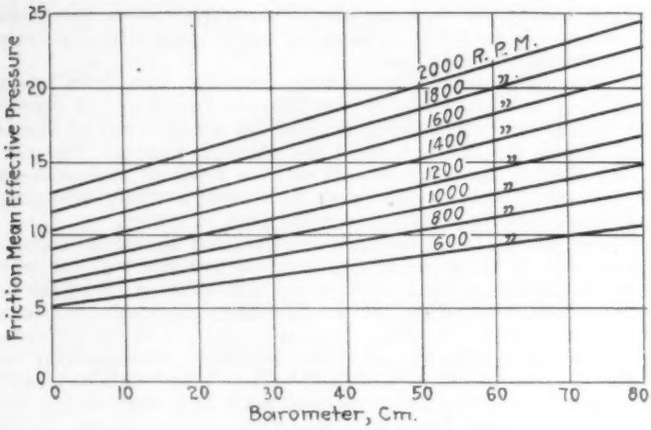


FIG. 1

If indicator cards were available, many things could be seen directly, whereas without the indicator it is necessary to use indirect methods to ascertain the effect of various factors. The change of an operating condition such as speed, air density or mixture ratio, affects the indicated power liberated by combustion inside the cylinder in a direct manner; but it may or may not change the power required to overcome friction losses. For example, a change of mixture ratio sufficient to decrease the brake power has probably not materially changed the friction, if the speed and air density remain constant, but a change of air density at constant speed and with a suitable mixture ratio will change not only the indicated power but the friction power as well, and there will be at least two causes for change of brake power. In other words, when studying a change of operating conditions, the effect upon indicated power is the fundamental relation and the effect upon brake power is only a most important by-product. The friction losses are thus a promising field for investigation, not only because they must be understood in order to be reduced but because, at present, we must know their total amount to obtain a measure of the energy liberated inside of the cylinder. The term friction as here used includes not only the piston and bearing friction but also the power required to operate the valves, pumps, ignition devices, etc., and the pumping losses to charge and scavenge the cylinder. It would appear that the friction as measured when the engine is being driven by an electric motor might not be the same as the friction when the engine is operating, because of the effect of the explosion pressures and temperatures, the effect of the fuel upon the cylinder-wall lubrication, and other features. The values of indicated power obtained by adding the brake and friction power appear to be a good measure of what would be obtained with an indicator.

TEST ANALYSES AND CURVES

Results from many tests were analyzed, studying the relation between speed, air density and friction torque, expressed as mean effective pressure. It was found that the friction mean effective pressure for a given air density was nearly a straight-line function of speed, and for a given speed it was also nearly a linear function of air density as shown in Figs. 1 and 2. The densities used in the tests ranged from 0.076 lb. per cu. ft. at ground level, or 75 cm. barometer, to 0.030 at about 30,000 ft. altitude, or less than 30 cm. barometer. By extending the curves of friction mean effective pressure for constant speed to zero density, a good idea was obtained of the friction when the pumping loss was zero. By subtracting the friction at zero density from the friction at another density and the same speed, a value was obtained which indicated the magnitude of the pumping loss. The estimates of the pumping losses thus obtained were directly proportional to the air density for a given speed. The pumping losses would be expected to vary in this way because the piston displacement for a given speed or volume is constant, and the difference of pressure between suction and exhaust, or the pressure per unit area, is proportional to the density. The volu-

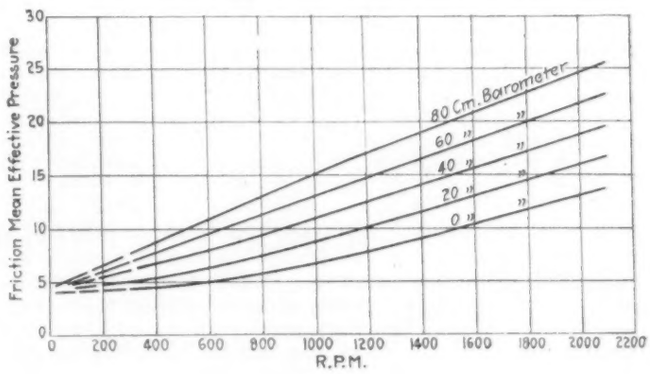


FIG. 2

[1]Bureau of Standards, Washington.

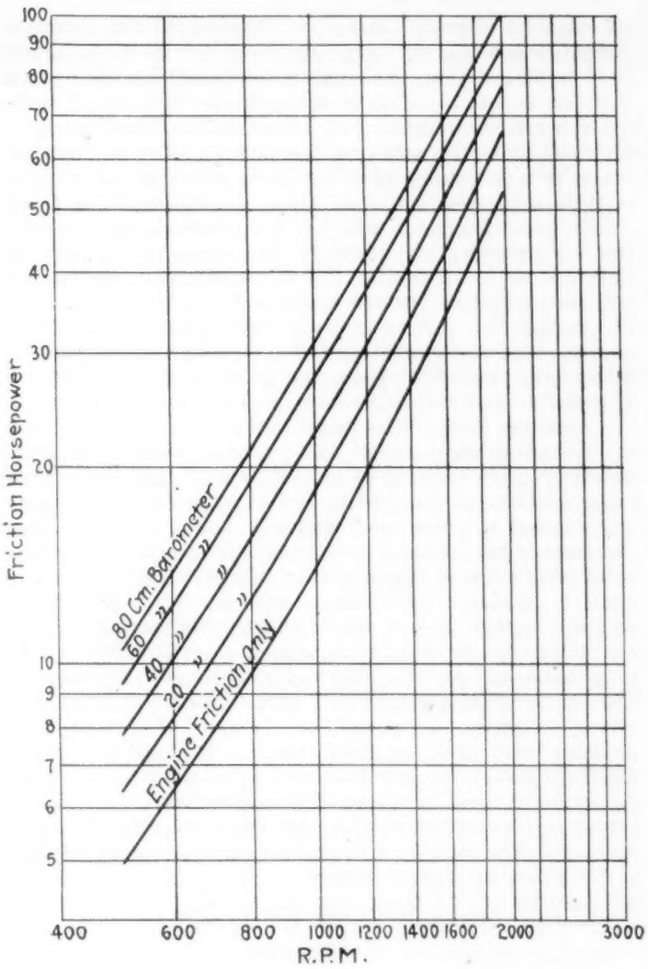


FIG. 3

metric efficiency enters as a factor, but if it decreases it will increase the pressure difference and decrease the density at the same time, thus its effect tends to be small. The subject of volumetric efficiency is very elusive and is not touched upon here. Insofar as possible, this analysis has been made to eliminate dealing with volumetric efficiency as such, or so as to consider it a result, not a cause.

Some tentative curves for variation of friction horsepower with speed are given in A Study of Airplane Engine Tests, Report No. 46, of the Fourth Annual Report of the National Advisory Committee for Aeronautics, page 23, plot 27. These curves were made from rather meager data, but indicated an increase of friction horsepower with speed raised to a fractional exponent, up to a critical speed, above which the friction horsepower increased with about the square of the speed. More recent work, based upon more complete and reliable data, indicates that the relationship between friction and speed is not so simple, although similar. The logarithmic plot of friction horsepower against revolutions per minute in Fig. 3 is a continuously curving line whose instantaneous slope at any speed is dependent upon the engine; but in general the friction horsepower increases more rapidly at higher speeds, being about with the square of the speeds for small speed changes at the rated speed of the airplane engines which were studied.

There has been some question as to the exact effect of change of air density upon the indicated power. In National Advisory Committee for Aeronautics Report No. 46, because of the lack of data on friction horsepower it was practically assumed that this relation was one of direct proportionality. In the work now being done, the indicated power has been closely approximated by adding together the brake and friction powers. The form of the indicated horsepower versus density curves on pages 8 to 11 of report No. 46 are substantially confirmed in Fig. 4, in which the 5.4 compression ratio is indicated by a cross and the 7.2 ratio by a circle. Adverse conditions are usually encountered at extreme altitudes, a persistent difficulty being the rich mixture supplied by stock carbueters. This causes the indicated power to decrease faster than the density, above 20,000 ft.

Another way of showing the effect of density upon indicated power is to plot the indicated work against the weight of air supplied as in Fig. 5, in which the plotting points are shown by numerals indicating the ratio of air to fuel in the mixture. The points obtained with an open throttle have a circle around the numerals, while the others are from a throttled engine with the indicated mean effective pressure corrected to approximately the equivalent open-throttle value. The correction is based upon the pressure difference between the exhaust and intake manifolds. This method of plotting eliminates to a large extent the effect of speed and permits comparison of different engines. The resulting curve is not exactly a straight line. Excessively rich, or lean, mixtures will reduce the amount of work obtained from a pound of air and, with a given mixture ratio, when the weight of air supplied is reduced by decreasing the density, the power obtained from a pound of air is reduced. Some exhaust-gas analyses were available; these indicate that the denser the air the greater is the per-

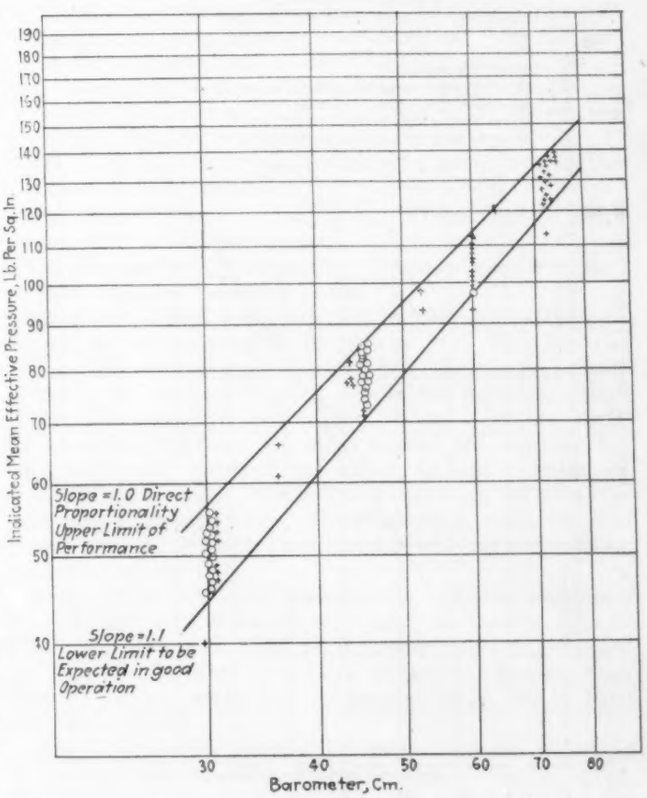
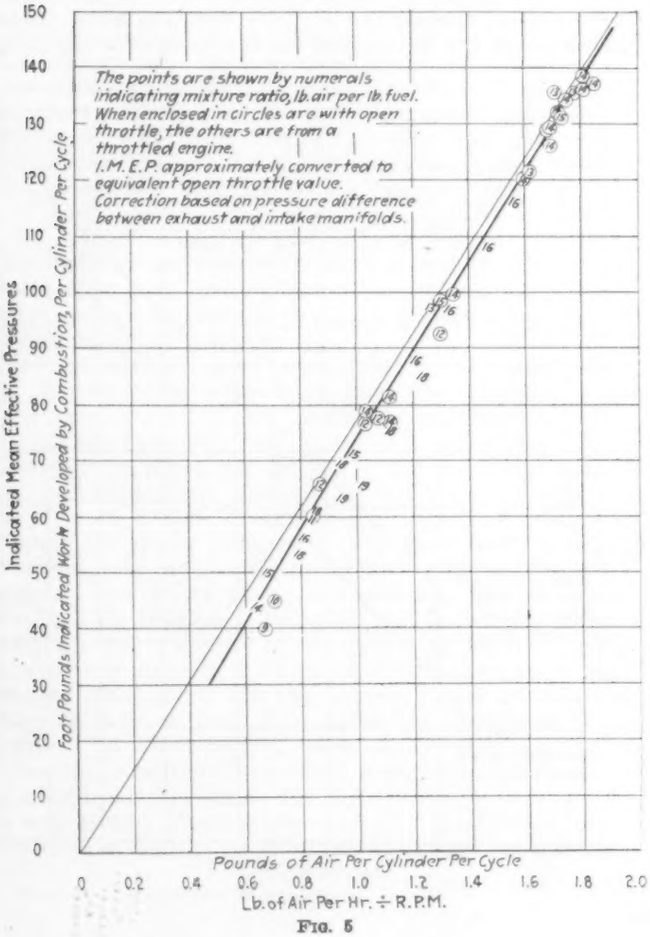

Indicated Mean Effective Pressure, Lb. Per Sq. In.
Barometer, Cm.
Slope = 1.0 Direct Proportionality Upper Limit of Performance
Slope = 1.1 Lower Limit to be Expected in good Operation

FIG. 4

centage actually used in the combustion. An approximation of the efficiency of combustion, or the degree of utilization of the air, was obtained from the amount of excess oxygen in the exhaust gas at various altitudes. The coefficient of utilization of the air at various altitudes was applied to the numerical values of the pounds of air supplied per cylinder per cycle, giving an idea of how the indicated work changed with change of the weight of air utilized in the combustion, shown by the lighter line on Fig. 5. It seems that they are directly proportional and the relation indicates no work at no air, whereas the relation of indicated work versus the weight of air supplied is a curve starting at no work for some air and becoming asymptotic to the direct proportionality, such as is shown by the heavier line on Fig. 5. Apparently, the indicated work obtainable is directly proportional to the weight of air actually combining with the fuel, providing combustion is complete and the air and fuel are in suitable proportions. The proper proportions of air to gasoline for various altitudes are not definitely known, although it is believed that altitude has little effect. Much work has been reported recently, in engineering circles, upon the effect of change of mixture ratio upon power and thermal efficiency. The combustion is dealing with what can be called an effective mixture ratio, which cannot be directly measured. The usual measured mixture ratio includes more fuel than the effective mixture ratio, depending upon the kind of fuel, carburetion, distribution, speed, etc. Perhaps the difference between the actual and effective ratios is small in some cases.

The foot-pounds of indicated work obtained per pound of gasoline supplied steadily increases as the mixture ratio is made leaner, up to mixture ratios of 20 lb. of air to 1 lb. of gasoline. For still leaner mixtures the engine becomes erratic. A curve showing the relation of indicated work to weight of air, such as that in Fig. 5, is arithmetically the same as one showing the relation of work per pound of gasoline to mixture ratio, or the pounds of air per pound of gasoline. However, in some of the tests the weight of air was changed by altering the air density; in others by changing the speed; in still others by changing the mixture ratio or the air temperature at a constant speed and pressure. The conditions of the test may alter the appearance of the curves. Some of the latter tests, with changing mixture ratios, were plotted to the coordinates of work per pound of gasoline and mixture ratio. For the runs with varying mixture ratio, the foot-pounds of indicated work per pound of air supplied was found to be small at rich mixtures, such as 9 lb. of air to 1 lb. of gasoline, rising to a maximum at about 15 to 1 and then decreasing again. The leanest mixture employed was about 22 to 1. An increase of the compression ratio will increase the work obtainable from a pound of air. The efficiency of combustion increases with increase of density. If change of speed enters, it is a minor effect. The data available are not complete enough to answer quantitatively questions as to the possible effect of altitude or compression. The mixture ratio giving just sufficient oxygen for complete combustion of this gasoline is about 15.3 to 1. The gasoline used in all of these tests is of high volatility, meeting the 1918 specifications for aviation gasoline. No account could be taken of the quantity of oil which enters into combustion, although the exhaust-gas analyses and other evidences indicate that the quantity may be too great to neglect safely.


The points are shown by numerals indicating mixture ratio, lb. air per lb. fuel.
When enclosed in circles are with open throttle, the others are from a throttled engine.
I.M.E.P. approximately converted to equivalent open throttle value.
Correction based on pressure difference between exhaust and intake manifolds.
Indicated Mean Effective Pressures
Foot Pounds Indicated Work Developed by Combustion Per Cylinder Per Cycle
Pounds of Air Per Cylinder Per Cycle
Lb. of Air Per Hr. ÷ R.P.M.
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
FIG. 5

HEAT BALANCE AND LOSSES

Another interesting relation was shown on some tests wherein the temperature of the entering air was changed. The indicated work obtainable from either a pound of air or a pound of gasoline is independent of the temperature of the charge in the manifold, for temperatures from 10 to 120 deg. fahr. This may not be true for still lower temperatures, as this gasoline does not seem to carburet well when the air entering is below 0 deg. fahr. Concerning the heat balance of an engine, the use of either the higher or lower heating value of the gasoline supplied as 100 per cent is open to serious objection, largely because changes in the air-to-fuel ratio alter the completeness of combustion and because the efficiency of combustion also is affected by change of the density of the charge at the time of ignition, the effect of altitude or compression ratio. The heat balance really should be based upon the heat made available by combustion.

S. W. Sparrow has already suggested the use of ratios of jacket and exhaust losses to the brake horsepower which work out very well for showing some relations. Carrying this idea further, heat balances were computed using the heat accounted for in the exhaust, jacket and brake, as 100 per cent instead of the heat supplied in the gasoline. The heat thus accounted for is nearly equal to the heat made available by combustion, the difference being the radiation, conduction and convection losses, a matter of only a few per cent. The amount of heat carried away by the cooling of the lubricating oil was roughly measured on one engine, and was about one-half of 1 per cent of the heat supplied in the gasoline. For compression ratios of about 5.4, the indicated

power is about 34 per cent and the exhaust loss about 53 per cent of the heat accounted for, no systematic changes being noted for changes of speed, altitude or minor changes of mixture ratio.

Some computations have been made by Dr. Donald MacKenzie, based upon theoretical considerations and the exhaust-gas analyses at various altitudes. For the exhaust-gas analyses available, the mixture was proportioned for maximum power. Other mixture ratios would give different gas analyses, so that his computations are not strictly applicable to the altitude tests with stock carbureters. Using his values for the energy to be expected from the combustion of 1 lb. of O_2, the heat available from 1 lb. of air was found. In connection with the weight of air supplied to the engine, the heat made available by combustion was computed. Another heat balance was based on this as 100 per cent, again giving consistent and nearly constant indicated thermal efficiencies of about 31 per cent and exhaust losses of about 50 per cent. These values appear to decrease slightly at altitude, possibly because the heat available was based upon maximum power mixtures while the tests had mixtures richer than the maximum power at altitude, with consequent less complete combustion.

The heat accounted for, that of the exhaust, jacket and brake, is less than the heat available, which is the weight of air supplied times the heat it makes available, by an amount of the order of 8 per cent at ground level. The residual by test, which is the heat supplied in the gasoline minus the heat accounted for, is of the order of 20 per cent at ground level. This indicates that about 12 per cent of the heat is lost in some manner. The radiation losses are probably of the order of 2 per cent. At 25,000-ft. altitude, the discrepancy between the heats supplied, available and accounted for, is greater.

The "air-standard" efficiency used as an ordinate in Fig. 6, or the efficiency of the Otto cycle, using air, assuming constant specific heat, is

$$1-\left(\frac{1}{\text{compression ratio}}\right)^{0.408}$$

Comparing the heat exhausted in the Otto cycle

$$\left(\frac{1}{\text{compression ratio}}\right)^{0.408}$$

and the heat actually discharged in the exhaust of the engines for the same compression ratio, excluding unburnt fuel, it is found that the percentages are practically identical when the percentage of actual engine exhaust is based upon the heat available from combustion. At various times tests have been made in the altitude laboratory upon engines with compression ratios ranging from 4.7 to 1 and 8.3 to 1. Taking the exhaust as a percentage of the heat supplied in the gasoline, it is found that the different compression ratios gave exhaust at ground level as approximately 95 per cent of the theoretical heat rejection; 85 per cent at 15,000 ft. and 80 per cent at 25,000-ft. altitude. When the exhaust losses are approximately corrected to the basis of heat generated inside of the cylinder, they apparently coincide with the theoretical rejection for that compression ratio, as shown in Fig. 6. This would indicate that an increased utilization of the energy supplied in fuel must be obtained by an increase of compression ratio and the efficiency of combustion, as it seems almost impossible to reduce the jacket losses to any appreciable extent.

The Discussion

R. M. Gaston:—Have you made any tests which show the comparative performance with the variation in jacket temperature?

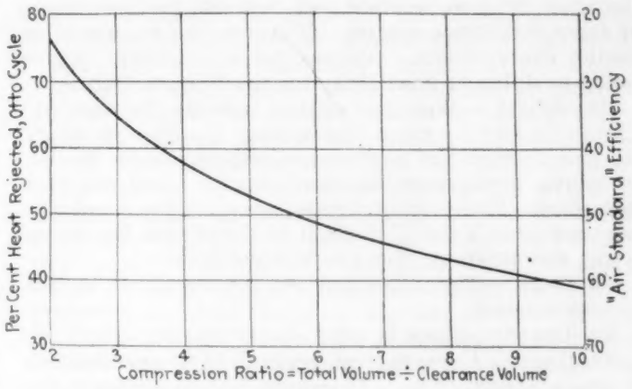


Fig. 6

V. R. Gage:—The tests for variations of jacket temperatures have been made, and so far we have been unable to get any very satisfactory answer. We know that the variation changes the friction considerably.

Mr. Gaston:—Which way does it vary the friction?

Mr. Gage:—As the jacket temperature increases, the friction decreases because the viscosity of the oil drops, but the change is not always consistent.

Mr. Gaston:—Were there any results which tended to indicate whether better thermal results accompany high temperatures? In other words, was a fuller expansion curve obtained?

Mr. Gage:—My impression is that this has not been carried out far enough to tell what does happen. As I said, changes in jacket temperature change the friction. We do not know what it is doing to the indicated power. We may be getting an increase of brake power by reducing the friction through the viscosity of the oil, but still the indicated power may remain constant. We will get better brake power, but if we originally used an oil of lighter viscosity we would have the same kind of an increase in brake power that was secured by increasing the jacket temperature.

Mr. Gaston:—Your results seem to indicate that the engines are over-cooled.

Mr. Gage:—I will not say that. These engines were run at about a 160 deg. outlet.

Mr. Gaston:—If the results are better when run hotter, why are they not over-cooled?

Mr. Gage:—My point was that hotter jackets thinned the oil down toward the danger point. The oil was selected for the probable range of jacket temperatures. Probably the largest friction loss is the piston friction. If we reduce the viscosity of the oils on a cylinder wall, we have less friction. In other words, the engines are lubricated with perhaps too heavy an oil, because we intend to play safe. We use too heavy an oil so as to take care of emergencies. These statements are my personal opinion, formed upon theory and rather meager experimental data.

S. Udale:—Were any experiments made to determine whether the wire-drawing was more noticeable at altitude? Was the falling off of the mean effective pressure at high speeds more noticeable at great altitudes than at low? For example, was it greater at 30,000 ft. than at ground level?

Mr. Gage:—That would be shown on the indicated horsepower curve. The indicated mean effective pressure is practically proportional to the density of the air. As we rise in the air, we reduce the pumping losses and

the other friction becomes less, but still the percentage of friction becomes greater. However, the amount is an engine characteristic. Curves for the Liberty engine would be different from those for the Hispano-Suiza.

MR. UDALE:—Was the critical velocity determined? I mean that with a given engine there is a limit in speed; the characteristic of any engine will eventually be flat. Of course, the average aeronautic engine is not run near that speed. Under those circumstances, if the speed was run up to such a point, would it be found that the horsepower was constant, that you had the peak?

MR. GAGE:—The volumetric efficiency falls off beyond a certain speed.

MR. UDALE:—There is a flat characteristic.

MR. GAGE:—Above that we begin to have more friction of the air getting in. It cannot get in through the passages.

MR. UDALE:—Was this investigated? That is important in certain classes of airplane engines.

MR. GAGE:—Yes, the Liberty engine is run to 2000 r.p.m. The Hispano-Suiza has a peculiar sort of engine characteristic that seemed to tend to continue increasing, at least up to 2200 r.p.m. Still, there is a considerable wire-drawing, or manifold depression on this engine, which increases with speed.

MR. UDALE:—Did density have any influence?

MR. GAGE:—Perhaps your point is covered in that run with the engine throttled, where corrections were applied in order to compare throttling with altitude effects. In other words, this change of the mean effective pressure with density is directly proportional to the density of the air at the beginning of the compression stroke. There is no difference, whether the density is changed by going up in the air or by throttling the engine, either intentionally or unintentionally as by manifold restrictions, except for the relative change of suction and exhaust pressures.

MR. UDALE:—My point is whether there would need to be any different proportions in the area of the passages than if designing for ground-level conditions. Is the viscosity of the air any higher?

MR. GAGE:—I cannot answer that last question definitely because the throttle runs have been made only at 5000, 10,000 and 15,000 ft. It would seem that the best proportions might be the same at all densities. For, although the velocity through the manifold increases at altitude, the friction of the air in passing through becomes less as it becomes less dense. My estimate is that the passages would not need to be changed much. This subject involves volumetric efficiency, which also includes heat transfer from jackets, cooling effects from evaporation of fuel and other things. It is hard to tell the net result of change of only one of the factors.

J. W. STACK:—Were your friction experiments carried on with Liberty-engine specification oil?

MR. GAGE:—Yes; mainly with Liberty aero oil.

MR. STACK:—Were viscosity comparisons made for different temperatures in the friction test?

MR. GAGE:—That subject has been investigated, but I cannot quote the viscosity figures. The actual viscosity, or temperature, of oil in the cylinder walls is not known, so no quantitative comparison of viscosity and engine friction can be made.

W. S. NATHAN:—What was the layout in the venturi, for measuring air? Was the venturi directly on the carbureter for measuring the entering air?

MR. GAGE:—That is a point which explains why some of the data do not plot as well as they should, especially in connection with the work per pound of air. The air is drawn into the chamber through a box on top, where cooling and heating coils are located; it goes from that box through a venturi meter into the chamber. The venturi meter is connected to the carbureter intake by semi-flexible connections.

MR. NATHAN:—You are dependent on the suction of the engine for the action in the venturi. Have you taken any account of the inaccuracies of the venturi under the pulsating flows?

MR. GAGE:—The pulsating flows with the engines used are not very great. They are not as much as we often experience when using the venturi. The fact is that the flexible connection between the venturi and the engine leaked a little air. I found that we can get a 3 per cent leakage under the maximum unbalanced conditions. The pressure in the carbureter intake is balanced against the chamber pressure, and maintained practically the same. The maximum leakage would be, perhaps, 3 per cent in or out, depending on whether the venturi is under greater or less pressure than the chamber.

MR. NATHAN:—I take issue with you there, because I know that some tests have been made in which it was found that any sort of a reciprocating engine, or pump or compressor, has a very serious effect on the accuracy of the venturi.

MR. GAGE:—That is very true and the slower the pulsation is the greater the difficulty, because we are reading a manometer which is going up and down. A damping device is put in to stop pulsations, and some kind of a mean is what is read. We are then reading a pressure difference which is the mean of the upper and lower values. What should be used is the mean of the square roots of the fluctuations, instead of the square root of the mean of the fluctuations; the larger the fluctuation the greater the error. With eight or twelve cylinders pulling, at 1800 r.p.m., we get a very steady pull on the venturi. It is not a really serious fluctuation. If we try to use a venturi on a duplex boiler pump, running 20 strokes per min., we will have trouble from pulsations.

J. JANICKI:—You mentioned that comparative tests were made on friction, trying to allot the relative percentages of piston, gear and other frictions. Can you give an approximate idea of what those relative friction losses were?

MR. GAGE:—I have gone no further than to allot a certain percentage to the pumping loss. The bearing losses are small. The pumping losses for ground density at normal speed run a little under 50 per cent of the total friction losses.

MR. SHUMACHER:—You mentioned a new type of indicator; will you describe it?

MR. GAGE:—That was described at the annual meeting of the Society held at New York City in Januray, 1920. The indicator being developed at the Bureau of Standards was primarily conceived for use inside the altitude chamber. This necessitated a long-distance control, as no person can work inside of the closed chamber when the engine is running. It is of the diaphragm type, fitting into a spark-plug hole, and is slightly larger than a spark-plug. The connection between the engine cylinder and the under side of the diaphragm consists of a number of small drilled holes surrounded by a water-jacket. These holes are of very small volume so as not to alter the compression space. The diaphragm is placed between supporting grids, both above and below, limiting the deflection to a few thousandths of an inch. In the center of the top grid is an insulated electrode connected in a circuit through a telephone receiver and

dry cell, the circuit being grounded at the diaphragm. The space above the diaphragm is connected to a pressure-tank or vacuum-pump system with indicating gages, so that a pressure can be applied, and measured, to balance the pressure on the under side exactly. A difference of a few tenths of a pound will be sufficient to allow or prevent contact of the diaphragm with the electrode, resulting in a click, or no click, in the telephone receiver. As so far described the device would be suitable only for maximum or minimum pressures. To obtain an indicator diagram, the electric circuit must include a commutator rotating with the engine or dynamometer shaft, and a brush contact adjustable to any crankshaft angle. The purpose of this timing device is to give a complete circuit through the telephone receiver only at the selected piston position, so that the cylinder pressure at this point can be balanced by the applied pressure. Thus, the pressures at each angle of the cycle can be measured, and an indicator diagram can be plotted from the data. This diagram will represent average pressures for the time consumed in taking the data.

MR. JANICKI:—Relative to the indicator, my experience has been in taking cards that the variation in the mixture gives various mean effective pressures. That is particularly shown on slow-running engines. In plotting the expansion curve with that type of indicator, would the factors or the average points obtained from that sort of a curve carry any great weight in real values in your opinion?

MR. GAGE:—Yes; the change in mixture ratio greatly affects the mean effective pressure.

MR. JANICKI:—Assuming an engine that is running at 500 r.p.m., before the pencil can be released from contact with the card in the ordinary indicator, six or seven or probably ten various expansion curves will have been drawn on that card, and they may vary 20 or 30 per cent. In plotting the curve, particularly on low-grade fuels, probably it is not so apparent with high-grade fuel, as you pick these average points, would that be a large factor in the work?

MR. GAGE:—With various mixture ratios, on the one-cylinder Liberty engine and on some of the smaller engines, a smooth expansion curve is obtained. It is not a broad band. The maximum variations of pressure on the several contemporary expansion lines occur at the beginning of the stroke, and there is practically no variation of the expansion lines after the middle of the stroke, even when there is a variation at the start. The range of mixtures covered was from ordinarily lean to quite rich. However, the very lean mixtures are erratic; they may not explode at all or they may give a fairly full card. Such mixtures would not be tolerated in normal operation.

In using a gas-engine indicator of the ordinary type, expansion lines such as just described are seldom obtained because of the inertia of the indicator parts and the periodic vibration of the spring. If the rise of pressure in the engine happens on an upswing of the vibrating parts, the resulting explosion and expansion line of the card is too high, and, similarly, the vibrations of the indicator may partially counteract the effects of explosion. There are many different periods of vibrations of the ordinary steam-engine-type indicator, just as there are various overtones of an organ pipe.

MR. JANICKI:—I wanted to clear up this point, at fairly constant speed and load, the fluctuations being small. The data obtained would be of value.

F. C. ZIESENHEIM:—What temperature and pressure correction should be used for correcting horsepower to standard conditions for general-purpose test work?

MR. GAGE:—I have had many discussions on that score. There are a large number of variables and we must get back to indicated horsepower to make any logical correction. It appears that if we consider indicated horsepower, the temperature will affect the power to be obtained mainly as temperature reduces the weight of charge, because the power is proportional to the weight of charge. The pressure correction is made in the same way, simply as the density affects the weight of charge drawn in. That assumes that the suction and exhaust pressures maintain the same relations to each other, no throttling change, but change of density by altitude or temperature. For brake horsepower, no rough-and-ready rule that I know of can be applied unless we figure it in advance for the particular engine.

J. G. ZIMMERMAN:—On the question of flame propagation which comes in so strongly in all high-speed work, has anything been done on comparative work with the various grades of fuel?

MR. GAGE:—Comparing flame propagation for different fuels, the only thing that has been done is a recent test, when benzol was studied, and also some commercial gasoline was used. On commercial gasoline the one-cylinder Liberty engine knocked very badly.

MR. ZIMMERMAN:—One report given out by the Bureau of Standards on flame propagation gave the speed as 30 meters per sec. Does that fluctuate with slight change in the composition of the fuel? I am inclined to think that, in many of the so-called high-speed low-grade-fuel engines, designers are encountering the problem of flame propagation without realizing what the trouble is. It is that the piston runs away from the flame if governed too high, in trying to operate on lower-grade mixtures.

MR. GAGE:—In the *Proceedings of the Institute of Automobile Engineers*[2] Professor Bone discusses selective burning and shows how the hydrocarbons break down into one product or another, passing through the different alcohols, etc., and finally may end with CO_2 and H_2O, if the combustion is completed. I am inclined to believe that in burning kerosenes some compounds ignite very quickly, but many of them hang fire and continue to burn, and there may be something of the effect you mention. We have been watching the flame propagation, in regard to detonation, but I must refer that explanation to Dr. MacKenzie.

MR. ZIMMERMAN:—Do you not think that the knock is due to the explosion of the first fuel constituents and that then difficulties come in because the mixture is not completely burned on account of the dilution of the remainder?

MR. GAGE:—Yes.

MR. ZIMMERMAN:—How much of the apparently delayed burning is due to the fact that we have a liquid instead of a vapor? That is, we have an imperfectly vaporized fuel in this heavier grade.

MR. GAGE:—That enters to a large extent, but the other factor is there, no matter if we do have the fuel vaporized, although I may be mistaken. I am basing this opinion upon what I have read, and my information has come mainly from British sources. Even if we have the fuel completely vaporized, we will have some of the effect of delayed burning.

MR. ZIMMERMAN:—It will be made much worse by imperfect vaporization, will it not?

MR. GAGE:—I should judge so.

MR. JANICKI:—I conducted some experiments in which I burned the gases at sub-stage, not supplying sufficient

[2]Paper entitled the Combustion of Hydrocarbons by W. A. Bone, vol. I, p. 7.

air at the first stage to complete the combustion, and obtained a sort of gasifying effect. I found that I could maintain a flame propagation at approximately 100 lb. per sq. in., open flow to the atmosphere, which gave me an influx of about 600 ft. per sec. at the secondary stage. I did this by first burning the charge and reducing it to a gas, then burning it a second time.

CHAIRMAN DENT PARRETT:—You have covered the point of unused oxygen in the exhaust gas; have you any figures of how that varies in accordance with conditions?

MR. GAGE:—The information on that subject is from tests with wide-open throttle and maximum power mixtures. Under these conditions, apparently about 98 per cent of the oxygen was used on the ground, falling off to perhaps 88 per cent at 20,000 or 30,000-ft. altitude. These values are qualitative, not quantitative. I hope that we may eventually have really definite information concerning combustion and exhaust-gas analysis. It is a very important phase of the work.

M. A. SMITH:—What was the explosion pressure on that engine? Could you record that pressure with the indicator you used?

MR. GAGE:—I cannot say definitely, especially in regard to these engines in the altitude laboratory. I have seen between 500 and 700 lb. per sq. in. on the one-cylinder Liberty engine when it was knocking, with commercial gasoline. It dropped down considerably below that when we again used export grade aviation gasoline.

SPENCER'S PLACE IN EDUCATION

THE extent of Herbert Spencer's influence can best be appraised by a statement of the success that his recommendations have achieved. Spencer, however, was only one of many who for the last sixty years have been preaching the same doctrine. But the lucidity of his style, the apparently smooth-running logic and his ever-recurring emphasis on the same point have probably gained for his essays a larger audience than a more technical work could have done. In England it has taken the full measure of the sixty years that has elapsed since the appearance of the essays, and a war in addition, to bring home to the public the importance of giving greater attention to the sciences in the schools. Slowly but surely the subject has found a place for itself in the curriculum, but the war revealed the lamentable deficiency that still exists. For the preservation of life the country has now provided a generous system of medical inspection and treatment, and the study of hygiene has been introduced into the elementary schools; instruction in the rearing of children is furnished not only in schools for mothers but in the housewifery courses in both elementary and secondary schools, and preparation for citizenship is being undertaken more consciously by a reform of the history courses and textbooks, following wholeheartedly the lines recommended by Spencer. But if Spencer is coming into his own in his own country, it is only partially so, for experience has proved that the sciences alone do not suffice for complete living and that Spencer's leisure subjects weigh perhaps more than the technical in the scheme of life today.

Nowhere have Spencer's theories of education been better developed than in this country. It would be difficult to make out a case for direct influence, but there is a remarkable parallelism between Spencer's categories and the objectives of secondary education enunciated by a national commission on the reorganization of high schools. These objectives are declared to be health, command of fundamental processes, worthy home-membership, vocation, citizenship, worthy use of leisure and ethical character. Spencer thus stands vindicated.—I. L. Kandel in *The Evening Sun* (New York).

DIE CASTINGS MADE FOR WAR PURPOSES

IN a paper presented at a recent meeting of the American Institute of Mining Engineers, Charles Pack[1] defined die castings as those made by forcing molten metal under pressure into a metallic mold or die. The fundamental principles of the process have been known and practised for many years. The simplest application is embodied in the modern linotype machine in which molten metal, usually a tin-lead alloy, is forced into a metallic mold under pressure derived from a piston and cylinder immersed in the molten metal.

Die casting had their most severe test in 1917 and 1918, when most of the castings produced were used directly or indirectly in the Government's war program. A partial list of die casting applications for this purpose follows:

Breather-tubes and other metal parts for gas masks
Lewis machine-guns; 100 die-cast parts to each gun
Four of the most vital parts of the Browning machine-gun
Entire housing of binoculars
Army truck, tank and airplane parts, including those of the ignition system, carbureter, gasoline-regulating devices, steering-wheel accessories, ball-bearing cages, bearings and speed indicators
Complete signal pistols
Submersible bombs, some designs containing as many as ten die-cast parts
Hand and rifle grenades; every grenade manufactured in the United States contained one or more die castings
Airpane drop bombs; one or more die-cast parts
Trench mortar shells with die-cast plug
Surgical instruments, including hair clippers and respiratory devices

In many instances die-cast parts were used where their failure would result in serious loss of life. Not one failure of a die casting has been reported, according to Mr. Pack.

Although the art of die casting is comparatively new and to a large extent unknown, the Patent Office records contain a number of patents on this subject. What is probably the first machine designed for the production of commercial die castings was patented in 1902 and greatly resembles the linotype casting machine in its principle of operation. The paper traces the development in the construction of machines for producing the castings, and the progress made in the construction of the die.

[1]Secretary and chief chemist, Doehler Die-Casting Co., Brooklyn, N. Y.

Automotive Vehicles in the Great War

By CLARENCE J. WEST[1] (*Non-Member*)

STRICTLY speaking, the foundation of the departure from the horse-drawn type used previous to our entry in the war to mechanical power in the form of 5-ton, 10-ton and even heavier, traction engines had been laid before 1917, in the Mexican campaign of 1916 and in experiments that had been conducted at the Rock Island Arsenal. These tests were neither intensive nor extensive because of the lack of funds.

> "COMPLETE motorization of field artillery and its ammunition supply is almost certain to be one of the far-reaching and highly important results of our country's experience in its participation in the past war."[2]

At the outset, it became evident that two general types would be required by the Army so far as ordnance was concerned: one for far-advanced work, for hauling artillery over the worst possible kind of shell-torn and water-soaked earth, and the other for bringing up ammunition, supplies, equipment for repairs and the like in less advanced zones and areas, but over roads and country that had been cut and hacked and made almost impassable by the activities of the contending forces.

The vehicles developed, included a standard four-wheel drive commercial truck, five sizes each of four-wheel and caterpillar tractor and a self-propelled caterpillar gun-mount. The standard four-wheel-drive commercial truck, modified to meet the special needs of the service, was adopted immediately after war began. Special bodies and equipment were worked out and perfected. These were exceedingly complicated, as many as 700 items of equipment on a single truck being needed in some cases.

Five different types of four-wheel tractor were developed for particular uses. These were 1½ and 3-ton anti-aircraft; 3-ton 75-mm. field gun; 4-ton mobile repair shop, and the 10-ton small tank. Five sizes of caterpillar tractor, 2½, 5, 10, 15 and 20-ton, were also developed. Of these the last two were adapted from commercial types, but special designs were made for the 2½, 5, and 10-ton types.

Throughout the production of tractors in the war period, there was continuous and persistent experimentation on self-propelled caterpillar gun-mounts, on which guns are mounted directly on the tractors. The great gun on a caterpillar mount fires its death-dealing projectile and almost before the shot has reached its destination, the mount has moved the gun to another point. This makes it difficult for the enemy's artillery to get its range. Among the guns mounted in this way were the 8-in. and 240-mm. howitzers and the 155-mm. gun.

AUTOMOBILES AND MOTOR TRUCKS

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TANKS

The tank, more than any other weapon born of the great war, can be called the joint enterprise of America, France and Great Britain. An American produced the fundamental invention, the caterpillar traction device, which enables the fortress to move. A Frenchman took the idea from this and evolved the tank as an engine of war. The British first used the terrifying monster in actual fighting. The tank as an idea shared the experience of many another war invention in being skeptically received by the conservative experts. The British Navy produced the first ones in England, but to the British Army belongs the glory of having first used them in actual fighting. Brought forth as a surprise, the tanks made an effective début in the great British drive for Cambrai.

The first tank program consisted in the construction of two types; one, a large size, Mark VIII, 8-ton, typical of that used by the British and capable of containing a dozen men, and the other a 6-ton patterned after the French Renault two-man model. In the summer and fall of 1918 this program was augmented by the development of two entirely new types of tank. One was a two-man tank weighing 3 tons, built by the Ford Motor Co., which had a speed of 8 m. p. h. The other was a successor to the French Renault, to carry three men instead of two and to mount a machine-gun and a 37-mm. gun. This was to cost less than the original Renault and to have a greater fighting power.

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TRAINING OF AERIAL OBSERVERS

THE Air Service is responsible for the provision of aerial observation for the Army, and is charged with the training of all aerial observers, both airplane and balloon. Officers designated for this duty will be commissioned in or detailed for duty with the Air Service. They will be trained in Air Service schools and in the schools of such other arms as may be necessary.

As a preliminary to becoming a flying officer all Air Service officers will attend a pilot school where the course will include the instruction formerly given at ground schools and instruction in aerial gunnery, theory of flying and flying training insofar as is necessary to develop flying officers so that they can be classified and sent to one of the specialist schools which are maintained to give training in observation, pursuit and bombardment work.

Having learned the fundamentals of flying, graduates of a pilot school selected for further training as observers will be sent to the Air Service Observation School. The course at this school will include flying training to develop observation pilots and observers of all types. Instruction will be given in map reading, visual and photographic reconnaissance, liaison with ground troops, surveillance, observation of and adjustment of artillery fire, maintenance and operation of the radio telephone and telegraph, intelligence, aerial gunnery and meteorology.

The same general policy will be followed in the case of balloon observers. Their training will be conducted at a balloon school. The course at such a school will include training in balloon maneuvering and observation.—Air Service News Letter.

THE WORK OF THE DEPARTMENT OF AGRICULTURE

SECRETARY of Agriculture Meredith, in an address before the American Newspaper Publishers' Association recently, said in part

> The Department of Agriculture makes for its stockholders, the people of the United States, a profit of several times 1000 per cent per year on all money invested in it. * * * As evidence that it is paying big returns I will give but a few typical items out of a large number that could be cited. We spent $250,000 establishing durum wheat in this country. The durum wheat now produced here is worth $50,000,000 a year. We spent less than $200,000 introducing a new kind of rice and establishing the industry in California. The rice crop in that State is now worth $21,000,000 annually. We spent $40,000 introducing Egyptian cotton, breeding it up and establishing the industry in arid regions of the Southwest. The American-Egyptian cotton crop each year is now worth $20,000,000 and is increasing every year. We discovered a serum that prevents hog cholera, and its use, as demonstrated by the Department, has reduced losses from that disease by $40,000,000 a year.

MAP SURVEYS FROM AIRPLANES

AIRPLANES will be used to map the Amazon Valley if the French are successful in surveying the rivers of French Guiana by airplane. Aircraft in Guiana will carry freight, mails and passengers in addition to the necessary mapping equipment.

AUTOMOBILES IN NEW YORK STATE

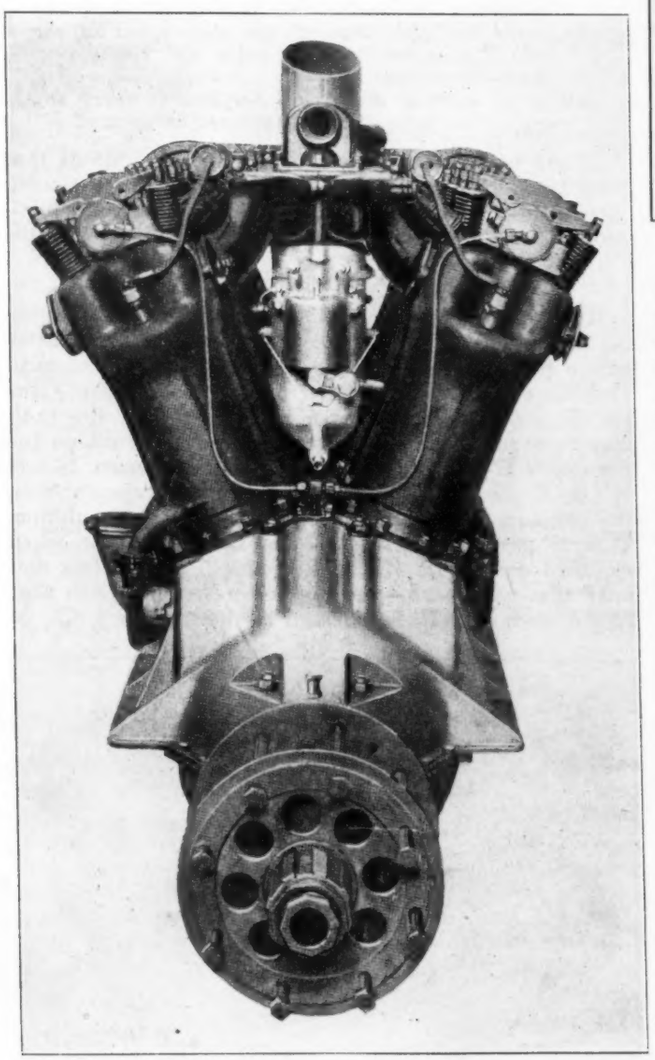
NEW YORK STATE reports 571,662 cars registered in 1919, an increase of 107,904 cars over 1918. The State leads all others in number of cars, having one for every sixteen residents. The automobile receipts for 1919 were approximately $6,000,000.

Engine Shape as Affecting Airplane Operation

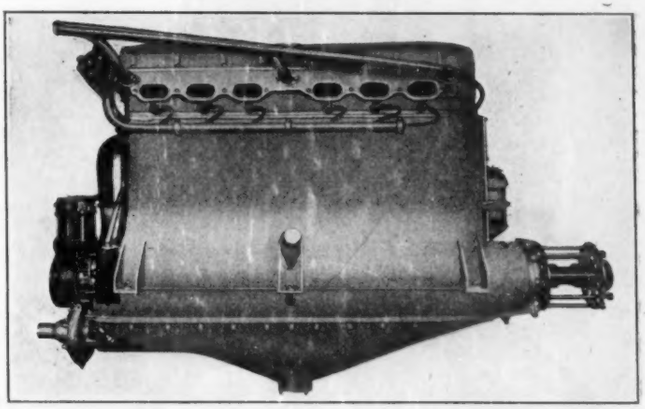
By GROVER C. LOENING[1] (*Member*)

AERONAUTIC MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

IT is generally accepted that speed is the *raison d'être* of the airplane, particularly as proved in the passenger air services maintained in Europe between London, Paris, Brussels, and other places. The annual report covering transportation by the largest British air-transport company, Airco, laid particular emphasis upon the greater value of the faster machines in its service. Granted that efficient loads can be carried, the expense, trouble and danger of the airplane are justified only when a load is carried at far greater speed than by any other means. That we may judge the progress made in aviation year by year largely by the increased speed attainable, seems to be a reasonable conclusion. Although this high speed is always first attained by small special racing machines, the history of aviation has shown that the same high speed is soon attained by machines carrying a more practical load.

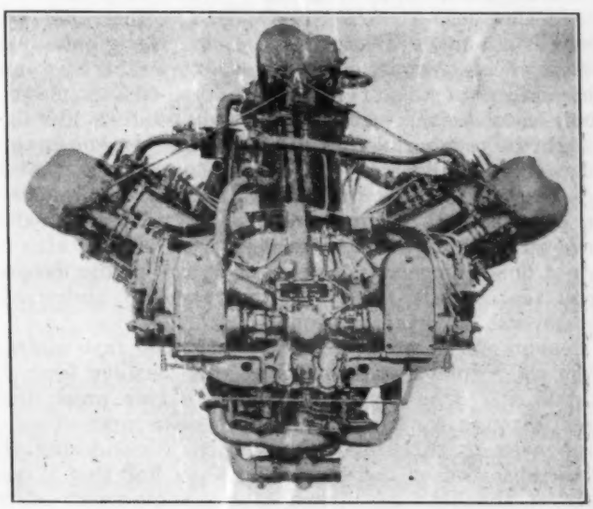


THE TWELVE-CYLINDER LIBERTY ENGINE



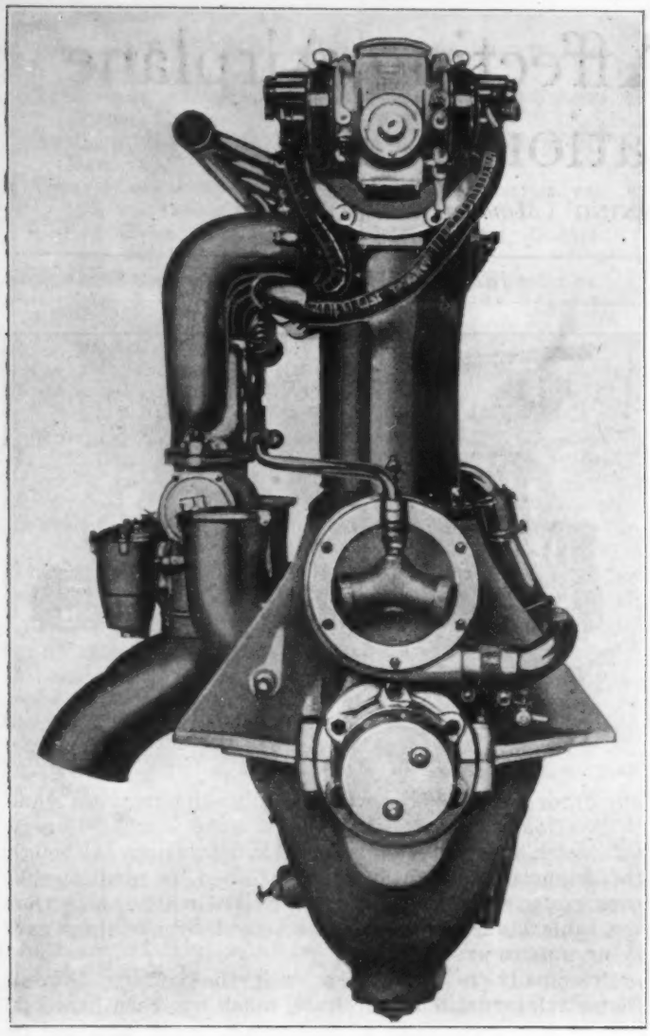
THE AEROMARINE SIX-CYLINDER ENGINE

Principally in connection with the coming Gordon Bennett International Air Race, much has been heard of late of the probability of 200 m.p.h. being attained in racing. The Nieuport single-seater, with an especially small wing area, is credited with about 190 m.p.h., although this machine in a closed circuit averaged about 170 m.p.h. It is interesting and possibly very valuable, therefore, to inquire into the relations of *power* and *resistance* as applied to small racing machines with aircraft engines that are available today.



THE NAPIER LION ENGINE

[1]Loening Aeronautical Engineering Corporation, New York City.



THE HALL-SCOTT L-6 ENGINE

One might crystallize the general off-hand sentiment of the aviation world with regard to fast machines by pointing out that the light-weight high-powered radial air-cooled engines are generally considered the coming type for small fast aircraft; while the large heavy high-powered water-cooled engines are generally placed in large slow load-carrying airplanes. Further than this, there is a distinct tendency on the part of engine builders to sacrifice some details for the purpose of lightening the weight of the engines, so that they can place in their catalogs an extravagant figure stating the light weight of the engine, "dry," in pounds per horsepower. The engine builder is only too likely to think that he has reached the goal required by the aircraft builder if he can make this figure low enough. In this paper, however, it is proposed to demonstrate that this attitude is not only erroneous, but actually tends to the development for aircraft of engines that are very undesirable for several important reasons.

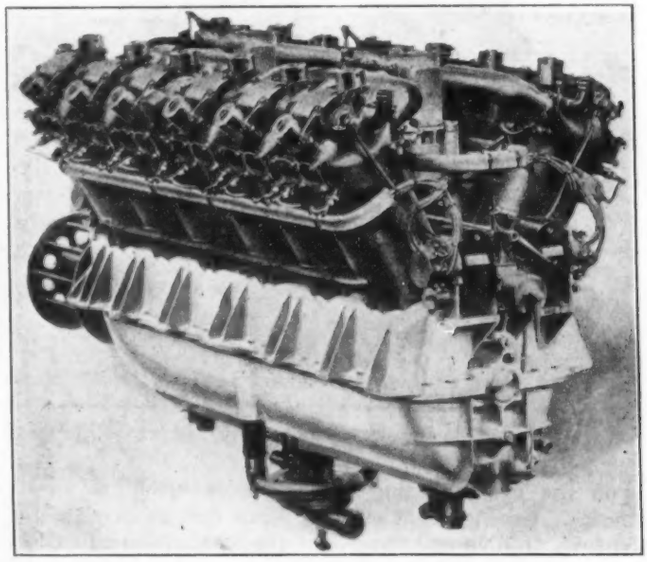
Leaving for a moment consideration of fast aircraft from the airplane standpoint, we can consider when all is said and done that the airplane engine must drive itself through the air, and requires some proportion of wing area to carry its own weight. Considering the power absorbed by the engine itself, we find that it consists of the head resistance of the engine and of its necessary water or oil radiators, due to their shape, and the drift on the wings that is chargeable to the weight of this powerplant. To separate these two items and examine into the desirability of various engines for the attainment of high speeds, we must analyze the cost of head resistance due to a heavy engine as against a light engine, and add the cost of head resistance caused by a bulky or a streamlined engine as the case may be. Let us simplify this problem by making the following reasonable, although admittedly not absolutely correct, assumptions:

(1) In high-powered, carefully-designed aircraft engines, the fuel consumption per horsepower is very nearly the same
(2) In applying maximum skill in airplane design, it is likely that the weight per horsepower of the airplane structure necessary to carry any of these engines will be about the same
(3) The propeller efficiency of the various engines can be considered practically the same, because we are examining primarily the high-speed conditions where the advantage of the slow speed of the geared propeller does not enter and might even prove detrimental
(4) In the drift of the wings necessary to carry any engine, the same lift/drift ratio can be assumed

It will be found on analyzing these assumptions that they mean that we do not penalize engines by placing them in different types of aircraft, and are thus justified in considering figures on a unit horsepower basis.

THE RADIATOR AND WING DRIFT

It has been found quite conclusively on many types of aircraft using water-cooled engines that, no matter where the radiator is placed, a certain amount of head resistance must be expended to get cooling, since the air must pass through the radiator. Placing the radiator in front of an engine, in an effort to combine the resistance of the two, merely makes it necessary to add to the size of the radiator by exactly the amount that the presence of the engine behind it blocks circulation. This is particularly true of the Liberty engine when mounted on the De Haviland-Four. Good practice dictates that we separate the radiator resistance from that of the engine itself, and assign to the necessary size of



THE 700-HP. FIAT ENGINE

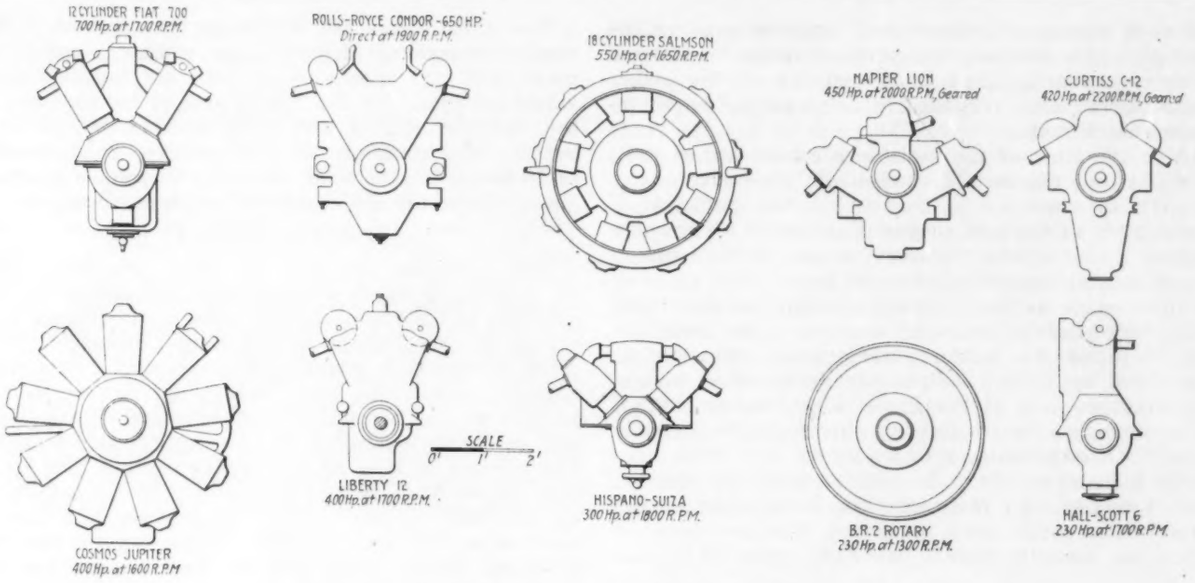


TABLE 2.—AIR-RESISTANCE CHARACTERISTICS OF ENGINES

Name	Power hp.	Number of Cylinders	Weight with Radiator, Water and Propeller, lb.	Weight, lb. per hp.	Frontal Area, sq. ft.	50 m. p. h.						100 m. p. h.						150 m. p. h.						200 m. p. h.					
						Engine Resistance, lb.	Radiator Area, sq. ft.[6]	Radiator Resistance, lb.	Wing Drift Resistance, lb.	Total Resistance, lb.	Resistance per hp., lb.	Engine Resistance, lb.	Radiator Area, sq. ft.[6]	Radiator Resistance, lb.	Wing Drift Resistance, lb.	Total Resistance, lb.	Resistance per hp., lb.	Engine Resistance, lb.	Radiator Area, sq. ft.[6]	Radiator Resistance, lb.	Wing Drift Resistance, lb.	Total Resistance, lb.	Resistance per hp., lb.	Engine Resistance, lb.	Radiator Area, sq. ft.[6]	Radiator Resistance, lb.	Wing Drift Resistance, lb.	Total Resistance, lb.	Resistance per hp., lb.
Fiat[2]	700	12	1,970	2.82	6.22	14.0	12.0	36.0	246	296	.42	56	9.7	116	180	352	0.50	126	7.3	197	180	503	0.72	224	4.9	235	197	656	0.94
Rolls-Royce Condor[3]	650	12	1,400	2.16	7.32	16.5	11.3	34.0	175	225	0.35	66	9.1	109	127	302	0.47	148	6.8	184	127	459	0.71	264	4.7	226	140	630	0.97
Salmson[4]	550	18	1,120	2.04	10.10	22.5	9.5	28.5	140	191	0.35	91	7.6	91	102	284	0.51	204	5.7	154	102	460	0.84	362	3.8	182	112	656	1.20
Napier Lion	450	12	1,040	2.30	5.68	12.8	7.8	23.5	130	166	0.37	51	6.2	75	94	220	0.49	115	4.7	127	94	336	0.75	204	3.1	149	104	457	1.02
Curtiss C-12	420	12	830	1.97	4.66	10.5	7.3	22.0	103	136	0.32	42	5.8	69	75	186	0.44	94	4.4	119	75	288	0.69	168	2.9	139	83	390	0.93
Cosmos-Jupiter[5]	400	9	690	1.73	12.65	28.3	...	...	86	114	0.28	114	...	...	63	177	0.44	256	...	...	63	319	0.80	458	...	...	69	527	1.32
Liberty	400	12	1,090	2.74	5.16	11.6	7.0	21.0	136	169	0.42	47	5.6	67	99	213	0.53	105	4.2	104	99	308	0.77	186	2.8	135	109	430	1.08
Hispano-Suiza	300	8	810	2.69	4.75	10.7	5.2	15.6	102	148	0.49	43	4.2	51	73	167	0.55	96	3.2	86	73	255	0.85	171	2.1	101	81	353	1.17
BR-2	230	9	530	2.30	9.62	21.7	...	...	66	88	0.37	87	...	...	48	135	0.59	195	...	...	48	243	1.05	346	...	...	53	399	1.73
Hall-Scott, L-6	220	6	620	2.75	3.87	8.7	4.0	12.0	79	100	0.43	35	3.2	38	57	130	0.56	78	2.4	65	57	200	0.87	139	1.6	77	63	279	1.21

[2]Direct drive
[3]Direct drive for high speed.
[4]Water-cooled; radial.
[5]Air-cooled: radial
[6]The value of the frontal area of the radiator in square inches per horsepower developed by the engine for the different speeds and the lift-drift ratio or drift resistance are given in Table 1.

radiator a reasonable frontal area in square inches per horsepower, varying with the speed.

A review of the sizes of various well-placed radiators gives the values for frontal areas presented in Table 1.

This reduction in the size of radiator, of course, involves the consideration that on a high-speed machine the radiator be retractable.

The weights of the engines shown in Table 2 are inclusive of radiator, water and propeller, complete. Part of the airplane's wing area must do its share of work in supporting the weight of the engine, and this work will cost a certain amount in head resistance represented by the drift of this proportion of the wing. We can arrive at this figure for any speed by dividing the weight of the engine by the lift/drift ratio at that speed, and from an examination of efficient wing structures the lift/drift ratios in Table 1 are assumed.

TABLE 1.

Speed, .m.hp.	Frontal Area of Radiator, per Horsepower sq. in.	Lift/Drift Ratio
50	2.5	1 to 8
100	2.0	1 to 11
150	1 5	1 to 11
200	1.0	1 to 10

In arriving at these values consideration has been given to the drift as a resistance not only of the wing section itself but of the complete bracing necessary to support it, which explains the less efficient value at 50 m.p.h. where flight would require a very large wing area and light wing loading which would necessitate a high head resistance in struts and wires.

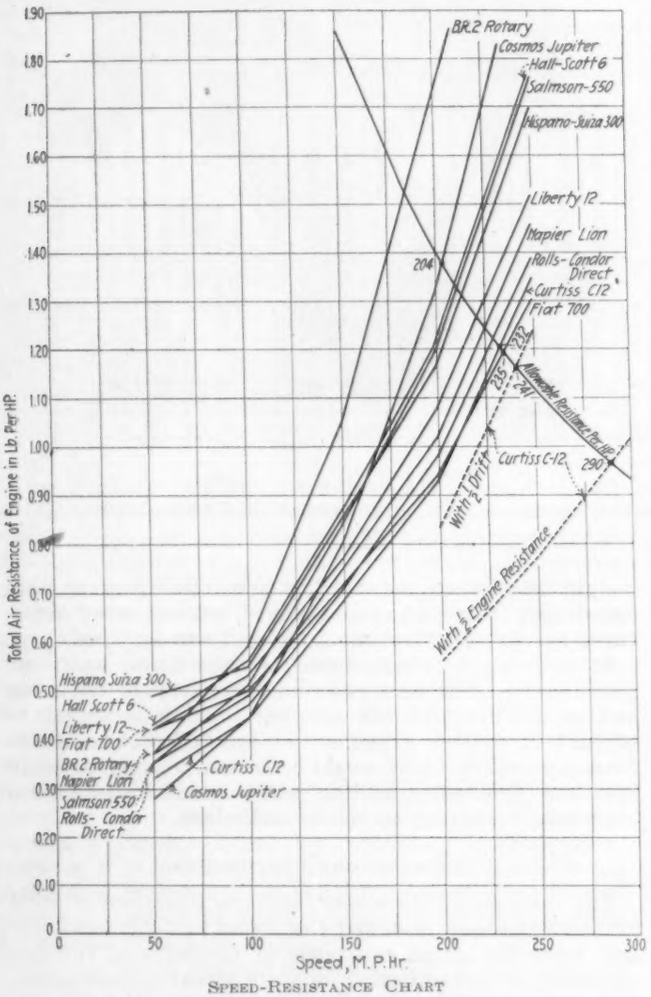
Resistance Coefficients

The resistances of various fuselages measured in wind tunnels have been reviewed and found to differ considerably from the actual resistance of fuselages of full-size airplanes, as determined from their actual performances. This is probably due to the ignoring of the slipstream effect. At any rate, a review of all these figures indicates that in the formula $R = KSV^2$ the value of the resistance coefficient K, for most fuselages, averages about 0.0009, where cross-sectional area is expressed in square feet and the speed V in miles per hour. This value has been adopted for all engines, a reasonable assumption if one

desires to obtain a better-shaped body by making the fuselage larger at one-third of its distance back from the engine, inasmuch as the resistance of the larger cross-sectional area very nearly balances the lower resistance coefficient.

An examination of the resistance coefficients of radiators discloses the fact that when the resistance of the headers and some piping is included, the coefficient K for radiators of the best shapes is at least 0.0012, where the frontal area of the radiator S is expressed in square feet and the air speed in miles per hour. New types of radiators, such as the Lamblin circular radiator, will modify this slightly, primarily because of the more efficient shape of the header arrangement; although, as pointed out by Colonel Bristow in an excellent article[7] on aircraft engines at the Paris Show, the amount of piping necessary to connect up this radiator probably would rob it of much of its advantage.

With the above data it becomes possible to establish a new quantity, the resistance per horsepower of the engine. How much more important this new quantity is than the quantity weight per horsepower of the engine, to which we have been giving so much attention, will readily be shown by a further examination of the various engines. Table 2 shows the characteristics of the engines which are representative of the latest developments.



SPEED-RESISTANCE CHART

This table shows the weight per horsepower of these engines complete, including the radiator, water, propeller, etc. At speeds of 50, 100, 150 and 200 m.p.h., values are given for the frontal area of the radiator, and the radiator, engine and drift resistances due to the weight of the engine, all of which are finally summed up to determine the total resistance in pounds per horsepower due to the shape, weight and type of engine.

THE SPEED-RESISTANCE CHART

The values derived from the table have been plotted on a chart in which the abscissas are speeds in miles per hour and the ordinates the total air resistance of the engine due to its shape and its weight as carried by the wing, expressed in pounds per horsepower. In a rather striking manner the chart brings out figures that are perhaps worthy of consideration by every engine builder and designer interested in developing higher speeds. The general opinion as to aircraft engines held by the aviation world is subject to considerable correction, for we find that the best engine for a heavy load-carrying machine at slow speeds is the Cosmos Jupiter, the latest air-cooled radial type; and the best engine for high speeds is the heavy, high-powered, water-cooled engine represented by the 700-hp. Fiat. Close to this we find the beautifully-shaped Curtiss C-12.

At about 100 m.p.h. all of the types of engine considered have very nearly the same air resistance. At 250 m.p.h., to which speed the chart has been carried, the differences are clear. The general quantitative picture presented by this chart shows us that the light air-cooled radial type, with a high head resistance, loses the value of its light weight as soon as its poor shape begins to absorb more of its power in resistance. The difficulty of getting high speeds out of rotary engines, for example, is obvious when it is realized that at speeds of only 80 m.p.h. the BR-2 rotary engine begins to become very much less efficient than the six-cylinder Hall-Scott engine of about the same horsepower.

To determine what high speeds the present available engines would permit under ideal conditions, we can lay off on the chart a curve showing the allowable resistance per horsepower. This forms a barrier beyond which we cannot go, simply because 1 hp. is itself entirely consumed by the allowable resistance. The values on the chart show the resistance per horsepower of the engine. Considering a high-speed airplane with practically no structural resistance other than that of the engine and the fuselage behind it, and with a landing gear practically eliminated as a resistance by being retracted, we could estimate that a load of fuel, the pilot and the airplane structure itself, would consume in the form of drift on the remainder of the wing area not already carrying the engine, about 25 per cent of the total available power. Thus 75 per cent of each horsepower in the engine is available to combat the engine's resistance and will permit this engine resistance to rise up to the figure that uses up the allowable pounds. Thus we arrive at a curve from the formula

$$\frac{\text{Horsepower} \times 375}{\text{Speed in miles per hour}} \times 0.75 = \text{Maximum allowable resistance in pounds.}$$

From this curve we can conclude that under ideal conditions, with reasonable extremes in design for the racing machine, we could obtain a high speed of 235 m.p.h. with the Fiat, 232 with the Curtiss C-12, gradually working down to 204 for the Cosmos, and 180 for the BR-2 rotary engine. It is seen, therefore, putting consideration of landing speed aside, that straightaway speeds of 200

[7] See *Aircraft Engineering*, January, 1920.

m.p.h. are distinctly possible. Of course, in a small circuit, the maneuvering ability of the machine would greatly modify this.

Resistance More Important than Weight

The chart permits an interesting demonstration when we take the figures for the Curtiss C-12 and assume first that by laborious work the weight of the engine is reduced to one-half its amount, which it is very doubtful could ever even be approached in this type of engine. Assuming such an extreme, however, we find the resistance per horsepower, when reduced as shown, permits an increase in speed from 232 to 241 m.p.h. or only 9 m.p.h. On the other hand, we can take this same engine and assume that, keeping its weight the same, we modify its structure so as to halve the head resistance of the engine itself, due to its shape. This change, which is entirely within the realm of possibility, would increase the speed to 290 m.p.h., and would show that if we could get a 420-hp. engine with a cross-sectional area permitting a good shape that would not be much over 2 ft. high and 9 in. wide, we could approach a speed of 300 m.p.h. Evidently, therefore, even admitting that some of the assumptions made necessary to derive this simple chart are apt to vary, we nevertheless find a lesson of the greatest importance which promises much in the future of aviation. This shows how much more important the head resistance of an engine is than its weight. Let us urge the builders, therefore, to abandon their unwarranted race for lighter weight per horsepower, bringing with it tremendous expense in construction, a lack of reliability and innumerable difficulties in service, and that they begin on a new line offering far greater possibilities by making the shape and disposition of their engines more suitable to airplanes, with low head resistance considered as a fundamental. An engine of sufficiently well-studied shape will permit greater weight, more reliability, and less construction expense. This will improve the practicability of airplanes to an enormous degree, and with it bring improved performance.

The Electric Scooter

An experimental model of electric scooter which has been brought out in England will attain a speed of 14 m.p.h. and cover about 40 miles on a single charging of the storage battery. It is described in a recent number of *The Electric Vehicle*, from which the accompanying description is taken.

The frame of the scooter is of duplex tubular construction so that a cradle is formed in the center of the frame. A ½-hp. electric motor which with a reducing gear forms a single unit is bolted to the rear part of the frame and drives the rear wheel, which is 12 in. in diameter, through a short chain. It is expected that the diameter of the wheels will be increased to 18 in. when the scooter is regularly placed on the market and the motor may be incorporated in the rear wheel. The battery, which delivers current at 8 volts, weighs about 112 lb. The cradle formed by the spreading of the two frame members supports the battery, which is readily detachable from the frame and can be moved on rollers to the charging point. It is expected that a charging plug will be provided on the frame of the commercial machines, thus making it possible for the battery to be charged without removing it. The control of the current from the battery to the motor is obtained by turning the right grip on the handle bar.

An Experimental Form of Electric Scooter

A motorcycle saddle and footboards of ample size are included in the equipment.

GERMAN PROGRESS IN AVIATION

An interesting report on German progress in aviation has been made by Col. William Hensley of the balloon and airship division of the Air Service. Colonel Hensley flew to Scotland on the return trip of the R-34 through the courtesy of the British Government, and shortly thereafter departed for Germany. He reports that the Germans gave him every opportunity to see their various creations in heavier and lighter-than-air craft and afforded him an opportunity to pilot the giant passenger airship Bodensee. He was shown through the Zeppelin works at Lewenthal where he saw the giant L-72 which was designed and constructed for the sole purpose of bombing New York. He sought out the pilot of this machine, learning that this man was the coolest, most daring and efficient of German war pilots and had successfully bombed London ten times, raked Dunkirk and caused great havoc on the Russian front early in the war.

The enormous airship is unique in many ways. To camouflage it to the minimum of visibility, the belly is painted black, its sides are splotched with cloud-effect gray, while the top is painted a medium amber color. At between 5000 and 10,000 ft. these colors fit in almost perfectly with the sky. The L-72 is 779 ft. long, has an 89-ft. beam and is 95 ft. high. It is propelled by six 260-hp. Mayback engines at a speed of 91 m.p.h. and the capacity of its fuel tanks is 11,000 gal., which gives a cruising radius of 9500 miles. The hydrogen capacity is 2,470,000 cu. ft. and the total lifting power is 86 tons, with 50 tons of this available as dispensable lifting power. The L-72 was designed to carry 5½ tons of bombs in addition to the crew, fuel supply and stores.—Air Service News Letter.

First Transcontinental Airplane Test

SEVENTY-FOUR entries were received for the transcontinental reliability and endurance test. Sixty-three taxied to the starting line, forty-eight at New York and fifteen at San Francisco. Of the eleven entrants who did not start, some were withdrawn from the test and some met with accidents en route to starting point. Of the forty-eight airplanes that started for San Francisco, four can hardly be considered as having been in the race. Two of them had trouble in the neighborhood of the Hazelhurst airdrome and the other two failed to reach the first control stop, Binghamton, N. Y.

For the purpose of making comparisons and basing percentages, it is considered that fifty-nine airplanes competed in the transcontinental reliability and endurance test, forty-four from New York and fifteen from San Francisco. Twenty-six arrived at San Francisco, making fifty-nine per cent of the starters to finish the east to west journey. Seven of the western starters reached New York or 46.6 per cent. Thirty-three of the fifty-nine or 55.9 per cent of the aviators, finished the first lap of the test.

The transcontinental reliability and endurance test was originally planned under rules published Sept. 23, 1919, to be across the continent one way. The idea was later conceived to have the flyers make the round trip, and this plan was definitely decided upon during the course of the first lap of the flight. Provision was made, however, that any pilot who did not desire to fly the second half of the trip was in no way obligated to do so. Therefore, of the thirty-three airplanes to complete the first half of the journey only seventeen were entered in the return flight. Of the twenty-six Eastern entries who arrived in San Francisco, twelve elected to return by the air route. Of the seven flyers landing on the east coast, five started for San Francisco by airplane within the rules of the test. Of the twelve Eastern flyers six, or fifty per cent, finished the round trip within the rules of the test. Two others arrived at the Eastern terminus outside of the rules, making a total of 66.6 per cent of the starters to negotiate the second lap of the course. Of the five flyers starting from New York, two got through to San Francisco, making a total of 40 per cent. It is an interesting comparison that 58.8 per cent of the aviators starting completed the last lap of the race as against 55.9 per cent who negotiated the first lap of the race.

The DH-4 was by far the most numerous entry in the transcontinental test. However, there were enough foreign-built airplanes entered to afford some very valuable comparisons. The Bristol fighter, equipped with a Rolls-Royce engine, piloted by Brigadier-General Charlton, British air attaché, had the misfortune to be damaged early in the test on account of a forced landing in rough country, and a very valuable comparison was lost. With the exception of one Le Pere, one Martin bomber, and the Bristol fighter mentioned above, all the other types of airplanes in the test were single seaters or DH-4's.

The number of airplanes starting from New York and San Francisco and the number completing one flight are given in the accompanying table together with the number that made the round trip irrespective of the starting point.

Name of Plane	Starting from New York		Starting from San Francisco		Round Trip	
	Number Starting	Number Finishing	Number Starting	Number Finishing	Number Starting	Number Finishing
Bristol, fighter	1	0	0	0	0	0
DH-4	36	23	10	5	14	7
Fokker	2	1	1	0	1	1
Le Pere	0	0	1	0	0	0
Martin bomber	1	0	0	0	0	0
SE-5	2	1	3	2	2	2
Spad	1	1	0	0	0	0
SVA	1	0	0	0	0	0

Engines

In actual number the Liberty engine far exceeded all other competitors in the first transcontinental reliability and endurance test, there being fifty-three used in four types of plane, the DH-4, DH-9, Martin bomber, and the Le Pere. On the whole its performance can be considered very satisfactory, although one is constrained, after very careful consideration of all the circumstances, to arrive at the conclusion that the Liberty engine cannot run full out for more than 40 hr. On the other hand, it appears that with careful nursing to insure running at the point of least vibration, be the number of revolutions what they may, the engine will run over 100 hr. without overhaul. While it is desirable to put a machine to the test demanded of it in this contest, one must remember that even on active service, airplanes return to their base and receive far more careful inspection, with resulting necessary overhauls, than could be expected under the circumstances of this contest. Care should be taken, therefore, in estimating the performance of the engines of this contest that this very important factor is taken into consideration.

Few forced landings can be attributed to a failure of the engine itself. Usually dirty feeds, faulty ignition, or the fracture of oil, water or gasoline lines caused the breakdown, but while these are part of the engine they are, as it were, the trimmings and can readily be strengthened or corrected with little expense or further research. In comparing the reliability, for instance, of this engine with the German Mercedes, one should look at the result of the "round trip" handicap event. It is significant that in this event the two Liberties, one flown by Lieutenant Pearson, the other by Lieutenant Maynard, were both removed and replaced with a new engine in making the performance, while the German Mercedes, coming third, stood the test throughout. One is quite justified in assuming that these three pilots flew the shortest course and got the most revolutions possible out of the engine even to the point of sacrificing reliability, and the relatively heavier German engine stood the racket best and from a point of reliability proved superior. Nevertheless, the Liberty engine itself is fundamentally

good, especially when we take into account the fact that it was produced in large quantities and standardized to a certain degree. Speaking of standardization, one can not but call attention to the necessity of complete standardization. Parts of the Lincoln engine should fit the Ford and parts of the Ford, the Packard, interchangeably. Before we claim complete standardization, this must be accomplished.

With regard to ignition, which includes plugs, certain general observations can be made. It is significant that every pilot at some time during the test had to change his battery, and so much ignition trouble was encountered in the test that it is believed manufacturers should provide a general system of ignition in the future embracing, as on high-priced cars, a set of high-tension magnetos in conjunction with the battery system with two sets of plugs. Mica plugs gave better satisfaction than porcelain, for they seemed better able to withstand the excessive and sudden variations of temperature, the rain, ice, snow and the constant load.

Little trouble was experienced with the oil system. The pump leads had all functioned well. Some pilots preferred castor to Liberty oil, but in either case many troubles arose from quanity rather than quality of oil, so that on the whole the oiling system must be put down as perfect. In the future, oil must be filtered without fail, for it can be assumed that when care is taken in the filtration no trouble will follow from this source.

With regard to carburetion little difficulty was experienced, and where it was encountered it could usually be attributed to dirty gasoline affecting its flow. This all goes to point out the importance of good and sufficient filters, with positive filtration. Complete failure of gasoline supply was due usually to filtration or to a broken gasoline lead. For two reasons flexible copper tubing seems the logical solution to the gas lead problem. First, it is durable, and, second, it insures a clean gas supply, whereas the rubber hosing sometimes breaks off and clogs the feed.

Slight but negligible troubles were encountered in the cooling system. In view of the fact that in the mountainous region bitter cold weather was experienced, this gives all the more reason for satisfaction. It would be well to provide a condenser to take care of the overflow from the radiators, but care must be taken in this overflow to insure that it does not freeze solid in cold weather. This was the cause of more than one delay and must be watched carefully. On active service either catalytic lamps or water circulating heaters should be provided for water-cooled stationary engines, to keep them warm and ready to take the air in the morning with no delay. Some leaky water-jackets on the engine itself were encountered, but nothing abnormal.

With regard to the Hispano-Suiza engine, three types were used, the 150-hp. low-compression, the 180-hp. high-compression, and the 220-hp. geared engine. A greater percentage of Hispanos made the one-way trip than any other engine in the test. The 180-hp. made the best showing of the three, in that Captain Donaldson, in his SE-5A, made the complete round-trip with the least engine trouble. The test showed without a doubt that with a little care, watching the point of vibration, the filters and the temperature, the high-compression Hispano-Suiza engine will stand up against fearful strain. Valve trouble was experienced, as every one expected, but to no greater extent than in a normal engine. When one considers that the pilots concerned were striving to get the largest number of revolutions consistent with lack of vibration, great credit must be given to the manufacturers for this product. Generally speaking, castor oil proved more satisfactory than Liberty in the Hispano, but this observation can not be taken as definite, as it will require an exhaustive study of all the circumstances to make this conclusion an undisputed fact.

The German Mercedes 160-hp. low-compression engine installed in the Fokker plane gave a wonderful performance. No spares were needed and only a few minor adjustments to the magnetos, jets and plug-points were made. Undoubtedly mica plugs must be used in the Mercedes engine. The best porcelain plug obtainable fell down in all cases and had to be replaced. Generally speaking, the performance of these water-cooled engines in this test points to the necessity of simplicity of all portions even, in some cases, to the point of elimination. If practicable, the water system must be done away with entirely before an engine can encounter with success the hard knocks of a contest of this nature. Its ignition system, too, must be simplified. Its carburetion must be designed not only from the standpoint of reliability but also of fuel economy.

The SVA Italian six-cylinder engine, with double ignition, can hardly be judged fairly, as no end of trouble was experienced in oil leads breaking. There is no record of other trouble in the engine itself, but as the machine was withdrawn at Des Moines as generally unserviceable and unfit to proceed farther, the necessary data are lacking and no comments can be made.

It is interesting to compare the different types of airplane in which the engines were installed. Faults of the DH-4 are so well known that they need not be touched on here. They have, however, been pretty well overcome in the new DH-4B. Ten of these machines were entered in the test, and the comments of the pilots go to show that the expense involved in altering them was well justified, if, from the point of security alone, the pilot's morale was greatly enhanced and the probability of the gas tank crushing him in the event of a forced landing no longer loomed before him.

Provision will have to be made in this machine to do away with the excessive wind pressure between pilot and observer. Active service has shown that every consideration must be given to the comfort of the personnel, both pilots and observers.

Planes

One objection applies to all DH-4 machines, a fault that was brought out forcibly; i. e., the undercarriage is improperly placed. A very slight alteration in design should do away with the tendency of this machine to nose up on a soft-ground landing. Cowlings, too, are defective on both types and are useless after 25 to 40 hr. running. They should be reinforced on the converted type. Some provision, too, will have to be introduced to strengthen the fittings between the center section struts and the upper longerons, and in some cases tension of the stagger wires seems to force the fitting into the upper longeron, weakening the structure considerably. The DH-9A is practically the same as the DH-4B. It has poorer visibility for landing, but is stronger and capable of carrying more useful load than any other DH type.

The SE-5A made a very wonderful showing in the test. Single-seater planes are usually designed to be short-lived and not intended for long continuous flights of this nature. In this test, however, it is safe to say that they gave less trouble than the DH-4 and seemed to have all the bad points in design worked out of them. The advantage of an adjustable horizontal stabilizer is

obvious to all pilots, but particularly in a single-seater of this nature. Captain Donaldson could not have made such a wonderful showing had he been unfamiliar with the use of the horizontal stabilizer and failed to use it. As it was, he used it at all altitudes and at all revolutions of his engine with advantage to the benefit of both engine and flying time.

The Le Pere plane is one of the staunchest entered in the test, but owing to the poor gasoline-feed system none got very far. One observation must be made, however, and that is that the propeller on the take-off is too close to the ground, making the machine unsuitable for active service airdromes. It is believed, too, that a little dihedral in a plane not only tends to better maneuverability, in that it can perform steep climbing turns at high altitudes with greater ease, but because it makes the machine easier to land. To a certain extent, too, it does away with the danger of a heavy machine of this nature falling off on one wing, and from the standpoint of economy, if from no other, it will probably have to be introduced into all war machines of the future.

The simple cheap construction of the Fokker and its peculiar wing section are both radical departures in airplane design, and designers will do well in the future to consider this machine and its very ingenious construction. For a long trip of this nature, necessitating quick refills, tanks must be made more accessible. The engine itself is very accessible; any part can be reached and worked upon with perfect ease.

Only one type of multi-engined machine entered; this was the Martin bomber. Its performance, up to the point where a forced landing put it out of the test, was wonderful. Despite its great load it kept up with the lighter ships. It is feared this ship would have experienced some difficulty in getting off Rawlins or Green River, but it must be remembered that the pilot could have gone direct from Cheyenne to Salt Lake City if necessary.

The accessories on all planes must be considered satisfactory, as no comments were received from the pilots. Tires seemed to give some trouble, especially on the DH-4 type machine. As the strength of the tire is more or less a matter of opinion on an airplane, breakages may be overlooked, for the number occurring was not above normal.

Eight DH-4B airplanes left Mineola on the west-bound trip of the transcontinental reliability and endurance test. Of this number two arrived at San Francisco. Of the others enough of them got far enough along in the test to report valuable information as to the performance of these remodeled DH-4's.

The DH-4B airplanes entered in the transcontinental test were rebuilt by the L. W. F. Engineering Co. The principal reconstruction feature is the placing of the pilot and passenger behind the engine and gas tank.

There is one point on which all pilots agree: that the position of the pilot behind the gasoline tank and the greatly strengthened center section give an added feeling of confidence in the airplane. In the case of wrecks, even when airplanes overturned, neither pilot nor passenger suffered injuries. All of the pilots speak of the particular advantage of having the passenger within speaking distance. None of the pilots operating these airplanes reported them as being more difficult to fly on account of the pilot's seat being well behind the center of gravity.

In fact, the favorable criticism was that better visibility was obtained and that the airplane was easier to land than the regular type of DH-4. It is the opinion of the pilots flying these ships that no good feature of the regular DH-4 has been sacrificed in the remodeled type.—Air Service Information Circular.

LANDING FIELDS NEEDED

IMAGINE the giant Leviathan having to search up and down our coast line trying to find a place to anchor in safety. The chances of the Leviathan surviving would be one to a thousand. Yet this is the same condition which faces aviation in the form of landing fields. What the harbor of New York means to the Leviathan the landing fields in cities mean to the future progress of commercial aerial transportation. We can have no real progress in aviation until we pave the way to safer flights and that depends on municipal landing fields, which in turn depend upon the support given by cities and State legislation. So far the Air Service has built a number of fields for training purposes, but they are situated far from towns. Commercially but few of these fields are of particular value. Aircraft manufacturers have tried to build several fields. A few scattered fields are being maintained by their agents. Scattered fields will not do. The Air Service is in a position to lay out routes throughout the entire United States and has sufficient data on hand to help municipalities establish fields. A greater part of the air routes have already been laid out upon maps, all that is needed is action on the part of State and city governments. No doubt, when such action is taken, federal support will be given, by providing proper standardized hangars. A charge should be made against every plane using the field to help pay for its upkeep. It is cheaper to land on a good field and pay a nominal sum than to take chances of breaking the landing gear on a poor field and endangering lives of passengers.—Air Service News Letter.

THE 1920 MEMBERSHIP ROSTER

THE Membership Roster for 1920 has been issued and sent to all members. The last previous edition was issued in the summer of 1919, and all changes of address which were received prior to March 1 have been incorporated in the new list. While every effort has been made to have the information contained therein as accurate as possible, it is realized that in an industry which is as active as the automotive it is quite probable that the new book is not free from all errors. For this reason every member is urged to report to the office of the Society at New York City all instances where his name or address is not correctly printed.

MARCH EMPLOYMENT STATISTICS

THE Bureau of Labor Statistics received and tabulated reports concerning volume of employment in March, from representative establishments in thirteen industries. Figures for March, when compared with those from identical establishments for the same month of last year, show increases in number of people employed in eleven industries and decreases in two. The largest increases appear in woolen, men's ready-made clothing, cotton finishing and automobile manufacturing, respectively, while respective decreases of 12.6 and 8.2 per cent are shown in car building and repairing and cigar manufacture.

Comments Upon Fuels, Lubricants, Engine and Piston Performance

By WILLIAM C. DAVIDS[1] (*Member*)

MOTOR-BOAT MEETING PAPER

THE comments I shall make regarding fuels, lubricants and engine and piston performance, are suggested by some of the pertinent points appearing in the following papers presented at the 1920 Annual Meeting of the Society:

Tendencies in Engine Design (By L. H. Pomeroy)
Dilution of Engine Lubricants by Fuel (By Gustave A. Kramer)
Adapting Engines to the Use of Available Fuels (By J. G. Vincent)
Aluminum Piston Design (By E. G. Gunn)

The quotations are as stated and my comments thereon are appended.

MR. POMEROY:—If there is one thing certain, it is that a bad car is not salable very long, even by the most skilled sales department

The facts seem to support this statement in the main; yet engines are being sold in which the manufacturers have made little or no attempt to alleviate the inherent faults which have been mentioned in the papers being considered.

MR. POMEROY:—Engine balancing has also been the subject of much attention

Crankshafts have been hollowed, crank-throws counter-weighted, rods and pistons lightened, and much minute care has been taken to have the mechanical moving parts balanced. The major factors in balancing an engine during the development of power are those mentioned in the foregoing papers, including dry fuel thoroughly mixed and warmed at the time of ignition, an even and rapid flame-propagation rate and a proper lubrication of parts.

In these papers there is no mention of uniformity of compression or of the pressure required which will best facilitate the obtaining of a dry fuel mixture and an increase in temperature, so as to permit ease of ignition and a rapid and even flame-propagation rate. Uniform compression cannot be obtained without perfect valve and valve-seat contacts and having the pistons properly packed. Engines that have more or less variation of compression in the different cylinders, from 5 to 20 per cent frequently in actual operation, are much more out of balance than engines not having carefully balanced crankshaft, rods and pistons. The mechanical balancing of the engine can and should be made effective by packing the joint between the wall of the cylinders and the wall of the pistons so that it will not leak. A uniform compression can then be obtained and the pressure increased, so as to raise the temperature of the fuel, increase its dryness, impregnate the air with the gasoline in minute particles, provide ease of ignition and assist in a rapid flame-propagation rate.

MR. POMEROY:—In a mixture of gasoline and air, it apparently depends upon the pressure and chemical constitution of the gasoline at the instant of ignition rather than upon the temperature

Mr. Pomeroy presumably refers to the temperature obtained by preheating.

MR. VINCENT:—It is conceivable that a finely atomized mixture of liquid gasoline and air can be made to perform as well as a dry mixture

MR. POMEROY:—The use of aluminum pistons enables the inertia forces in a four-cylinder to be reduced very considerably below those in an eight-cylinder engine of the same capacity using cast-iron pistons and if aluminum connecting-rods also are used the wear and tear on the engine is cut literally in half at the source

Yet in the face of this statement, manufacturers are this year abandoning the use of great quantities of pistons which are such an ally to the smooth, quiet and efficient operation of the engine. Is it not due to the fact that the aluminum pistons are more difficult to pack than cast iron and that sufficient care and thought have not been directed to sealing the joint between the cylinder and the piston wall?

MR. POMEROY:—The success attending the various departures from orthodox construction is a very useful object lesson that no established construction is beyond improvement

The method long in use, comprising the turning of grooves around and into the pistons and snapping into them a ring made of cast iron, of many different styles or patterns, merely because of previous practice, has been what might be termed orthodox construction. Is it not high time that these old methods were made obsolete and that pistons be packed in a practical manner?

MR. POMEROY:—The subject of gasoline deposition in the crankcase is one of more practical importance than a problem involving physical speculation. With prewar gasoline the maximum absorption was about 4 per cent. Nowadays, when fully one-third of standard gasoline does not vaporize under a temperature of 140 deg. cent. (284 deg. fahr.), deposition is much more serious

MR. VINCENT:—The third item in order of importance insofar as the owner is concerned, is the contamination of the lubricating oil by the fuel which passes the pistons. This is a serious problem, for few owners will go to the trouble of draining off the oil at comparatively short intervals. In consequence, the lubricating system soon becomes filled with a mixture of fuel and oil of little or no lubricating value

MR. KRAMER:—Parallel with the decline in the volatility of commercial gasoline, complaints have appeared with increasing frequency of engine lubrication troubles resulting from the dilution of the lubricating oil in engine crankcases. The trouble is particularly pronounced in tractor engines where economy demands the use of the cheapest possible grade of fuel. How much of the trouble reported is really caused by dilution of the lubricant would be difficult to trace. Nevertheless it must be admitted that the problem does exist and that it is becoming more serious with the steady decrease in volatility of internal-combustion engine fuel. Inasmuch as this decrease is due to an increased

[1]Supervising engineer, William Gardner & Co., Rutherford, N. J.

demand, no relief through an increase in volatility of the fuel is in sight. The situation must then be squarely faced by the engineers of the country and attacked from every direction that promises a solution of the problem

The first and most satisfactory solution of the problem is to prevent dilution of the oil

Moreover, even the best fitting pistons and rings allow some of the cylinder charge to leak into the crankcase during compression

The statements of these engineers definitely bring the seat of the trouble to the unobstructed passage from the combustion chamber to the crankcase, by way of the space between the walls of the cylinders and the walls of the pistons. If the best fitting pistons and rings allow passage of fuel or oil, it is evident that they do not function to accomplish their purpose and therefore are faulty in design, application or material. A definite theory should be evolved for packing the piston, and from this theory a standard method should be developed which will prove successful in practice. When this has been accomplished, the old orthodox rule will be greatly disturbed if not definitely abandoned. Mechanics will then become as accustomed to grinding piston packing rings to their seats on the flanges of the piston as they are now accustomed to grinding valves to their seats; this should be so, as the valves and the piston packing are holding against the same chamber content. Why favor one and neglect the other? Cylinder walls should be straight, round and well finished, so that the packing can readily obtain perfect contact with the cylinder walls and maintain such contact indefinitely.

MR KRAMER:—The saving effected with engines requiring a frequent renewal of the oil on account of excessive dilution, would soon pay for the cost of the additional equipment, even at the present high price of lubricants

The orthodox rings can be enumerated as the plain, the angle cut and the lap-joint types, either eccentric or concentric. The majority of engine manufacturers are using a ring of one of these forms. Practice for the past fifteen years has proved that the joint between the walls of the cylinders and the walls of the pistons cannot be closed with rings of these types. The statements of the authors, to which reference has already been made, support this statement. It is therefore apparent that the method of packing pistons which has been in vogue for years should be made obsolete and a more practical and efficient method devised.

The valves have a continuous seat surface. Such a surface is provided on the flanges of the grooves of the pistons and is applicable for the seating of piston-rings. The valves have a continuous face for seating and, when ground to the seat as mentioned, make a closed contact between the valve and the seat and prevent the passage of combustion-chamber content during compression.

Piston-rings have been produced that provide a continuous-ring seating face. If this face were ground to the seat of the piston-groove flange, in like manner to that in which a valve is ground to its seat, there would be no material passing that joint. It then remains to close the gap at the ends of the ring, and to seal those ends against the wall of the cylinder. When this is accomplished and the rings make full contact with the inner circumference of the cylinder, the gap between the piston wall and the cylinder wall will be closed. There should then be no passage of fuel or residue from the combustion chamber by way of the pistons. This method provides for the packing of pistons against compression, and against compression only. It does not follow that when a piston is practically packed against compression it is packed against suction also. For obvious reasons it is much more difficult to pack a piston against suction than to pack it against compression.

MR. GUNN:—When too much oil is thrown into the cylinder bores, tight-fitting pistons and special rings will not completely overcome the trouble

A similar statement was made by H. Cooke when discussing Diesel engines at the January, 1920, Pennsylvania Section Meeting. Each of these statements has reference to lubricating oil passing the piston and going up into the combustion chamber, producing the undesirable conditions with which all are familiar. To prevent the passage of the lubricant upward along the piston and into the combustion chamber, it will be necessary to pack the joint in like manner to that described for compression, except that the seat contacts of rings and groove flanges will need to be reversed and made at the top of the ring-groove flange, not at the bottom as for compression. When this has been accomplished, the problem of obtaining sufficient wall tension of the ring presents itself, for, unlike packing for compression, there is no compression back of the suction ring. Naturally, the suction ring would need to be in the first groove above the wrist-pin, functioning so as to shut off the passage of oil and air at that point and thus preventing its passage from the crankcase to the combustion chamber. The only pressure that would be effective against this suction ring, would be that of the difference between the atmospheric pressure in the crankcase and the suction vacuum in the combustion chamber. This, at maximum suction, seldom exceeds 22 in. of vacuum 18 times the area of the piston clearance in square inches, the sum of which is negligible for all practical purposes. It leaves the functioning of the ring dependable upon the inherent expansion tension which has been developed in the ring. Assuming that the tension of the ring is 10 lb. per sq. in. and that the ring is ¼ in. wide, there would be 2½-lb. pressure exerted per lineal inch of ring. This is sufficient pressure to hold the ring against the wall when oils having a viscosity of about 250 deg. are used, and sufficient drainage is provided through the wall of the piston to provide egress of all excess oil that is in transit between the cylinder and piston walls. When an oil having a greater viscosity is used, the pressure it creates against the ring increases to the extent that the ring is caused to collapse and recede into its groove, permitting the oil to pass on up and past the piston into the combustion chamber. In instances of this kind, it is practicable to place a second ring on the piston in like manner as the first, except that it will not be necessary to provide the same amount of drainage.

Mr. Cooke also stated that the Diesel-engine cylinder must be lubricated without excess, and that gravity lubrication is suitable for use on engines with trunk-type pistons. This becomes a very practical method of lubrication for the large-type engines when the pistons are packed in the practical manner here described, and is much more simple, efficient and cleaner than that of the spray system from the crankshaft.

Pistons that are lubricated by the oil-spray from the crankcase and are so poorly packed as to permit unconsumed fuel and combustion residue to pass to the crankcase, give off an offensive odor when the crankcase is opened. Commander Gibson, in charge of the Diesel engine of the German submarine U-117, at the Philadelphia Navy Yard, stated that he and his men could readily detect a good engine from a bad one by the odor it emitted.

MR. POMEROY:—Cleanness of design, both outside and inside, is being appreciated more every day. The day is rapidly approaching when the public will demand that the automobile shall not be a means of transportation only, but susceptible of artistic treatment in just the same degree as a yacht or a house. The first law of beauty in construction of any kind is that the part shall be the one best fitted for the purpose

Pack engine pistons practically, in the manner best suited for this purpose; eliminate the flow of fuel and lubricants past them; annihilate the tell-tale odor; prevent the waste of fuel and lubricants and improve the maintenance.

THE DISCUSSION

CHAIRMAN JOSEPH VAN BLERCK:—I think that Mr. Davids' views are well stated as regards stopping the oil from passing the pistons, but that as to keeping the unburned fuels from passing the piston, he is starting at the wrong end. With perfect combustion there need be no concern about the piston, as far as allowing the unburned fuels to pass it is concerned. I have been watching this. On marine engines there are water-jacket manifolds and they are necessary, but a great many engines have been ruined in the past by the building up of the lubricating oil in the crankcase, since we have been forced to contend with the heavier fuels. On the engine we are building we have a hot-spot manifold. We are satisfied that we have excellent combustion and that we have it immediately after the engine is started. The exhaust manifold will in some cases become fairly hot, but we feel that this slight advantage is well enough off-set to be disregarded when we consider the great advantage we are obtaining. We are not concerned about the pistons; the better pistons we can make the better we can pack them and the more oil we can circulate through the bearings. Some years ago when we first started the pressure oiling system our task was to keep the oil away from the cylinders; but as we made better pistons and better piston rings we were able to increase the oil pressure. We hope in the future to put considerably more oil through the bearings than we are able to do at present.

REPORT OF THE CANADIAN AIR BOARD

THE Air Board, which was authorized by an act of the Canadian Parliament passed June 6, 1919, has issued a report of its activities for the fiscal year ended March 31, 1920. The work of the Board is divided into three branches, a superintendent of flying operations, a superintendent of the certificate branch and a secretary, each having jurisdiction over one of the branches. The first controls all civil government flying, the second conducts that portion of the administration relating to the public and has charge of the licensing of the personnel, aircraft and air harbors, while the secretary is in charge of the internal office organization at the Board's headquarters in Ottawa.

Among the things that the Board has accomplished are the promulgation of regulations covering flying, a preliminary survey of the public service situation with a view to determining what functions could be performed more efficiently by aircraft than by existing methods, the taking over of the seaplane stations and the airdrome which were developed during the war, together with aircraft and equipment, and a study of the development of aeronautics in Canada and other countries. In addition, arrangements have been made for the undertaking of technical research for the development of aeronautics, the collection and distribution of meteorological information that will be of use in air navigation, the licensing of ground and aircraft wireless stations and the issuing of navigators' certificates to air pilots, the preparation of aeronautical maps and the organization of an air force.

CLIMB OF SERVICE TYPE DH TESTED AT LANGLEY

A SERIES of flights to determine the climbing ability of an ordinary service type of DH airplane was completed recently by Lieut.-Col. John N. Reynolds and Capt. Walter R. Lawson at Langley Field, Hampton, Va. A DH-4 was used on the first and second flights and a DH-4B on the third, neither plane being selected for climbing ability and the pilots having flown only once or twice previously. They carried full military load, minus the machine-guns and the camera which form a part of the regular service equipment.

A good average climb was charted which called for the first 5000 ft. to be made in 5 min., 10,000 ft. in 11½ min. and 15,000 ft. in 27½ min. When the first flight was made, it was noted that up to 4000 ft. the climb was very slow, due to overheating engine, but after passing 4000 ft. a consistent and fairly good climb was made. The third climb was a little better from 10,000 ft. up, while it was about the same from 3500 to 10,000 ft. and on the second climb up to 3500 ft. These climbs were not conducted with the intention of establishing an altitude record or a speed record for altitude, but merely with a view of determining the average climb that could be expected from a service type DH under ordinary conditions. Nevertheless, on the second flight an altitude of 19,000 ft. was reached in 45 min. This can be considered fairly good climbing.—Air Service News Letter.

The Still Engine

By Capt. Frank E. D. Acland[2] (*Non-Member*) *Illustrated with* Drawings

THERE are two methods of producing power by the combustion of fuel, either under boilers or within the main cylinders of combustion engines. The greater part of the world's power is still derived from steam, which, owing to its proved reliability and greater adaptability to the services demanded of it, holds the

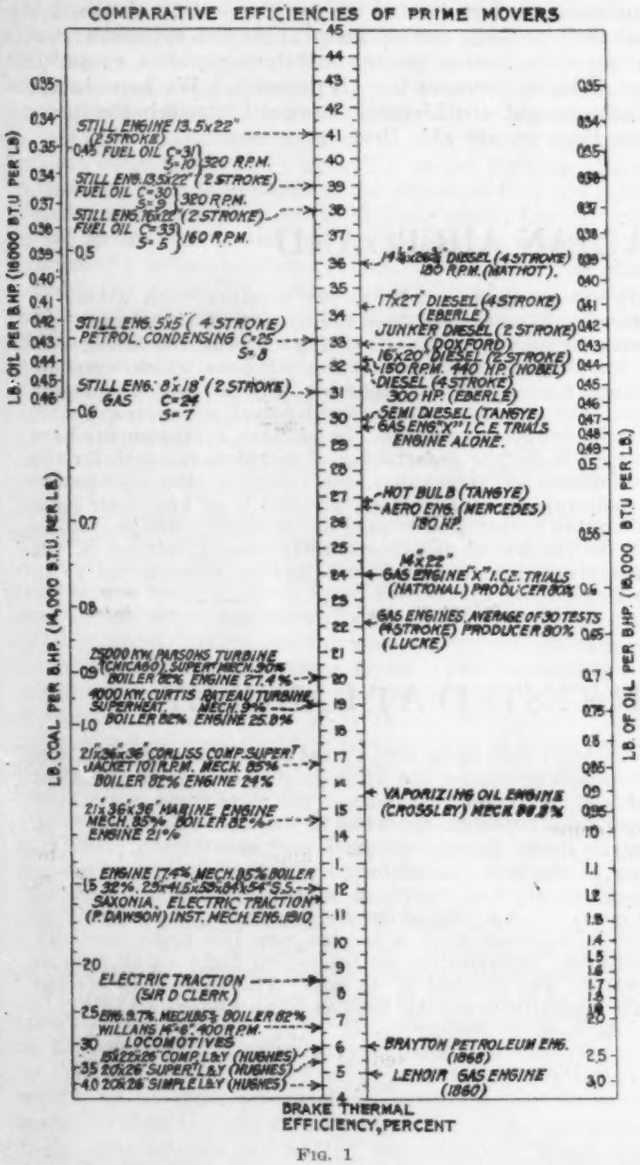

COMPARATIVE EFFICIENCIES OF PRIME MOVERS
LB. OIL PER B.HP. (18000 B.T.U. PER LB.)
LB. COAL PER B.HP. (14,000 B.T.U. PER LB.)
LB. OF OIL PER B.HP. (18,000 B.T.U. PER LB.)
BRAKE THERMAL EFFICIENCY, PERCENT
STILL ENGINE 13.5x22" (2 STROKE)
FUEL OIL C=31 S=10 320 R.P.M.
STILL ENG. 13.5x22" (2 STROKE)
FUEL OIL C=30 S=9 320 R.P.M.
STILL ENGS. 16x22" (2 STROKE)
FUEL OIL C=33 S=5 160 R.P.M.
STILL ENG. 5"x5" (4 STROKE)
PETROL. CONDENSING C=25 S=8
STILL ENG. 8"x18" (2 STROKE)
GAS C=24 S=7
25000 KW. PARSONS TURBINE (CHICAGO) SUPER'T MECH. 90% BOILER 82% ENGINE 27.4%
4000 KW. CURTIS RATEAU TURBINE, SUPERHEAT. MECH. 94% BOILER 82% ENGINE 25.8%
21"x36"x36" CORLISS COMP. SUPER'T JACKET 101 R.P.M. MECH. 85% BOILER 82% ENGINE 24%
21"x36"x36" MARINE ENGINE MECH. 85% BOILER 82% ENGINE 21%
ENGINE 17.4% MECH. 85% BOILER 32%. 23"x41.5"x55"x64"x54" S.S. SAXONIA. ELECTRIC TRACTION (P. DAWSON) INST. MECH. ENGS. 1910
ELECTRIC TRACTION (SIR D CLERK)
ENG. 9.7% MECH. 85% BOILER 82% WILLANS 14"x8" 400 R.P.M.
LOCOMOTIVES
15"x22"x26" COMP. L&Y (HUGHES)
20"x26" SUPER'T L&Y (HUGHES)
20"x26" SIMPLE L&Y (HUGHES)
14"x26" DIESEL (4 STROKE) 180 R.P.M. (NAT'HOT).
17"x27" DIESEL (4 STROKE) (EBERLE)
JUNKER DIESEL (2 STROKE) (OXFORD)
16"x20" DIESEL (2 STROKE) 150 R.P.M. 440 H.P. (NOBEL)
DIESEL (4 STROKE) 300 H.P. (EBERLE)
SEMI DIESEL (TANGYE)
GAS ENG. "X" I.C.E. TRIALS ENGINE ALONE.
HOT BULB (TANGYE)
AERO ENG. (MERCEDES) 180 H.P.
14"x22"
GAS ENGINE "X" I.C.E. TRIALS (NATIONAL) PRODUCER GAS
GAS ENGINES. AVERAGE OF 30 TESTS (4 STROKE) PRODUCER GAS (LUCKE)
VAPORIZING OIL ENGINE (CROSSLEY) MECH.
BRAYTON PETROLEUM ENG. (1868)
LENOIR GAS ENGINE (1860)

Fig. 1

field in competition with its rival, the internal-combustion engine. The steam engine exerts powerful starting efforts; puts trains or other masses into motion; operates at any speed from the start to its designed maximum; can develop more than its rated power at reduced speed; can carry severe overloads for long periods, and generally gives ample warning before ceasing to operate; but this is accomplished with a loss of 80 per cent, at least, of the heat energy contained in the fuel supplied to it, a loss which is irrecoverable. The internal-combustion engine shows a far higher heat efficiency, but cannot start itself without some external source of power; cannot develop its full power except at full speed; is a poor performer at low speeds; can only operate on moderate overloads for short periods; and may cease to operate owing to a small defect, without warning; so combustion engines have as yet made little progress in competition with steam in locomotive work, and have supplanted steam only to a limited extent in marine and stationary engines.

The conversion of heat into useful work, with the minimum of waste, depends upon the efficiency of the means employed; that is, it depends upon the losses in the heat cycle, and on the losses in the mechanism employed for producing the heat and converting it into power. The efficiency of a heat engine is the ratio of the heat converted into mechanical work to the total amount of heat which enters the engine. We are taught that, and we owe to our teachers a mass of accurate information about the laws of thermodynamics, thermal and ideal cycles, which serve as standards of comparison for every kind of heat engine; but they do little more than point out the way to getting the most out of the heat in an ideal engine, and ignore the losses in the creation and supply of the heat, or in the machine which converts it into mechanical work. It by no means follows that an engine which thermodynamically attains the highest indicated efficiency in relation to the ideal is in practice the most efficient for its purpose, or the most economical in fuel. Efficiency from the user's point of view is the ratio of the useful work to the total heat in the fuel used.

Fig. 1 shows the brake thermal efficiencies of various types of prime movers, steam, gas, and liquid fuel, with the fuel consumption in pounds per shaft horsepower-hour, based upon a calorific value of 14,000 B.t.u. per lb. for coal, and 18,000 B.t.u. for liquid fuel. The mechanical efficiencies of the various engines and heat efficiencies of the boiler and producer, when not expressly stated in the reports of the trials, are assumed to be as shown. Comparing the cycle of steam with that of combustion engines, the latter has two great advantages over the former. The fuel which imparts the heat to the working fluid is introduced directly into its working cylinder, and the temperatures and pressures are far above the limits of those possible in the steam engine and boiler. The steam engine suffers from heavy heat losses in the creation of its heat; it is forced to work at comparatively low temperatures and pressures, and, with super-heating, compounding and condensing added to it, has arrived at a point where further efficiency is well-nigh impossible.

Sir Dugald Clerk, in his paper submitted to the Royal Society of Arts in March, 1919, compared the thermal

[1] Extract from the *Journal of the Royal Society of Arts* (London).
[2] Retired British Army officer, London.

efficiency of the gas engine, which is 28 per cent, with an efficient producer, with that of the largest and best of existing steam turbines, which is 18.5 per cent, referred to the coal consumption under the boiler, and alluded to the probability of great improvements in gas engine efficiencies. The further recovery of thermal loss in the steam engine, or in the mechanism, is a difficult, if not an almost impossible task. In the internal-combustion engine all the losses at present existing are capable of some recovery, and certainly of considerable reduction. The maximum ideal efficiency of a heat engine is obtained where the difference existing between the highest and lowest temperatures of the working fluid is greatest in proportion to the maximum temperature, and here the internal-combustion engine, with an initial temperature higher than the furnace temperature of the boiler and even higher than the melting point of cast iron, is capable of realizing better thermal conditions than any other form of heat engine; but in its turn it suffers from two disadvantages, it ejects its working fluid at a temperature too high for ideal conditions, and it loses heat energy to a regrettable extent in the cooling of its cylinder. The result obtained in practice from the two cycles separately, based on their best performances after half a century of intensive development, is that in the steam engine there is a loss of over 80 per cent of the heat contained in the fuel, and in the combustion engine of 60 per cent.

The recovery and the efficient use of the waste has been the work of many years of patient research by William Joseph Still and others associated with him, and has resulted in the design and construction of a variety of engines which bear out the correctness of his principles, and point to a vast field of further practical application. The possibility of combining in one engine the superior thermal cycle at the high temperatures and pressures of the combustion engine with the low thermal cycle of steam to deal with its rejected heat, and, in the same engine, to add the superior working advantages of the steam engine, was the basis of his work. The development of the internal-combustion engine has included many proposals and attempts to utilize the heat going to waste in the exhaust and cooling water; but while in existing engines some proportion of the heat can be usefully recovered as steam from the exhaust gases, the cooling water from the jacket is of little value, owing to its low temperature, and the efficiency of the engine itself is not augmented. If, however, the temperature of the cooling water could be maintained at that of steam at useful pressure, the efficiency of the engine would be improved and the weight of steam usefully increased.

The Engine Described

The Still engine is an engine capable of using, in its main working cylinder, any form of liquid or gaseous fuel hitherto employed; it makes use of the recoverable heat which passes through the surfaces of the combustion cylinder as well as into the exhaust gases, for the evaporation of steam, which steam is expanded in the combustion cylinder itself on one side of the main piston, the combustion stroke acting on the other side. It increases the power of the engine and reduces the consumption of the fuel per horsepower developed. Its primary object is not to use the waste heat for raising steam, but first to use it in improving the thermal conditions of the working cylinder, and so insure the maximum efficiency from the fuel burnt within it, diminishing, as a consequence, the heat lost in that operation. Since the maximum efficiency is obtained by combustion of the fuel in the cylinder, and the minimum by the evaporation of the water in the steam generator, it is evident that the larger the quantity of steam which can be generated per horsepower developed by the combustion cycle, the lower must be the heat efficiency of the whole machine. Internal-combustion engines are kept cool by the circulation of cold water around their cylinders; the heat thus absorbed causes a rise in temperature of the water as it travels through the jacket, so that the cylinder is subjected to temperature differences and heat stresses, which are an abiding source of trouble and difficulty to the designer.

In the Still engine (See Fig. 2) the jacket and cooling water form part of the circulating system of a steam generator, which may be an integral part of the engine, or external to it. The cooling water therefore enters and leaves the jacket at a constant temperature, regulated by the pressure of the steam; the cooling being effected by converting the water into steam without raising its tem-

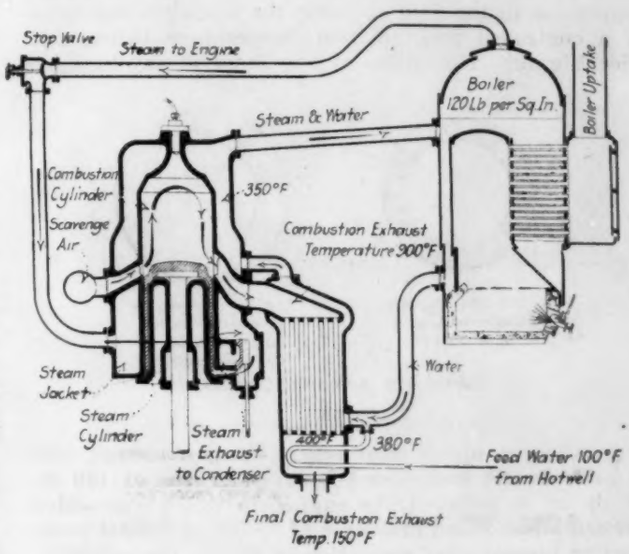
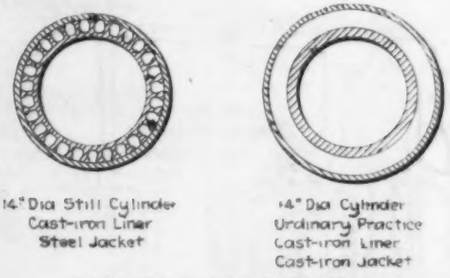


Fig. 2

perature. Excluding the radiation losses, which are kept low by lagging, all the heat which passes through the walls is thus usefully recovered in the water as steam. The temperature of the cylinder wall is uniform over the whole of its exterior surface, and the heat lost to the cooling water at each stage of the cycle, compression, combustion, and expansion, is diminished. During compression, owing to the walls being at steam temperature, the incoming charge picks up heat instead of losing it, during the greater part of the stroke. This is an advantage of the greatest value to the heavy-oil types of Still engine, where an air charge is taken in at the full outstroke and is compressed to a pressure where its increased temperature insures the certain ignition and combustion of the fuel which is injected into it. During combustion and expansion, the uniform and higher mean temperature of the wall reduces the heat lost to the jacket water. Some of the heat thus economized adds to the useful work on the piston, the remainder passing out in the exhaust gases for recovery.

To insure the maintenance, in a practical and reliable manner, of the temperature conditions which produce this efficiency during the combustion cycle, a

departure from the design and construction of the cylinders of normal internal-combustion engines is imperative; they have hitherto been made of cast iron, of a thickness sufficient to resist the working and thermal stresses thrown upon them, including occasional heavy loads caused by preignition of the explosive charge. With these thick walls or liners, the temperature difference between their inner and outer surfaces, which is essential if the surplus heat is to be carried off, can only be obtained safely by the circulation of water at low temperature through the jacket; this is especially the case in cylinders of considerable diameter, or capable of high power per swept volume. The cylinder of a Still engine consists of an inner liner, which is approximately one-third to one-fourth of the usual thickness; it is ribbed externally so as to add to its conducting surface and provide suitable passage for the cooling water, and it is reinforced by an outer hoop capable of withstanding the highest pressures to be met with in working. The stresses due, in ordinary practice, to the cold water at the inlet and the hotter water at the outlet, are suppressed in the Still cylinder, the cooling water being at a controlled and uniform temperature throughout. (See Fig. 3.) No failure of a cylinder of any kind has



COMPARISON OF CYLINDER CONSTRUCTION

FIG. 3

occurred, even under most severe, even abnormal, test conditions, with mean combustion pressures of 180 lb. per sq. in. in a two-stroke engine, to which was added overload steam mean pressures of 70 lb.; or a total mean effective pressure per revolution of 250 lb. per sq. in.

STEAM FROM WASTE HEAT

In gas and oil engines of constant-volume and constant-pressure types, the combined losses in radiation, cooling water and exhaust gases, range between 75 and 65 per cent. The highest indicated thermal efficiency claimed under test conditions with a four-stroke Mathot Diesel engine of 300 b.hp., at three-quarter load, is 47 per cent or 36 per cent brake efficiency. If 4 per cent is allowed for radiation, 49 per cent of the total heat is available for recovery, and if 10 per cent efficiency is assumed for the steam cycle, the brake thermal efficiency of an engine giving this high result would be raised by 10 per cent of 49 = 4.9; i.e., 36 + 4.9 = 41 per cent; but there is no reason why the steam generated and used under the conditions of the Still system should be limited to so low a figure. Fifteen per cent seems a more reasonable assumption and even a higher figure may be anticipated, in which case a brake thermal efficiency of 44 per cent should be possible in a complete installation. Such a statement can only be warranted by realizing the method by which steam is produced and used in this engine.

The Still engine may be of the constant-volume or constant-pressure type, or a combination of both; its losses to the cooling water are not the same as in a normal engine of either type, except insofar that they vary with the type, cycle, efficiency of the combustion stroke and the load. At normal and full loads such heat units, in a Still engine, as pass into the jacket water, which is at steam temperature and pressure, are lessened and are wholly recovered without loss, radiation excluded, in overcoming the latent heat of the water, and give off their steam in the steam space in proportion to the heat flow at those loads. At lower loads less steam is produced, until at still lower loads no steam at all is measurable. In other words, the jacket losses are practically eliminated.

The exhaust gases take a subsidiary but important part in the cycle; their usefulness in ordinary combustion engines, in raising steam, is limited to the amount of heat recoverable between the initial temperature of the exhaust and that of say 50 deg. fahr. above the steam temperature, after which the whole volume passes away to atmosphere at a still useful temperature, less a small percentage available for feedwater heating. But in the Still engine the exhaust gases, after raising their quantum of steam, are employed in preheating all the water required for the steam generated in the jacket water and in the generator. Trials at full efficiency over long periods and steady loads show terminal stack temperatures as low as 150 deg. fahr. The heat efficiency of the combined cycles is, therefore, exceedingly good, with an initial temperature of over 2000 deg. fahr., and a final exhaust to atmosphere at 150 deg. fahr.

The quantity of steam capable of being generated from "waste heat" depends upon the efficiency of the combustion cycle and on the load. Some years of experimental work prove that the weight of steam recovered may vary from a maximum of about 7 lb. per b.hp.-hr. developed by the combustion cycle of a four-stroke constant-volume engine at full load to a minimum at light loads which is hardly measurable, and which only balances the loss due to radiation. In Fig. 4 the relation existing between the output from combustion alone and from the steam generated by its waste heat gives the mean

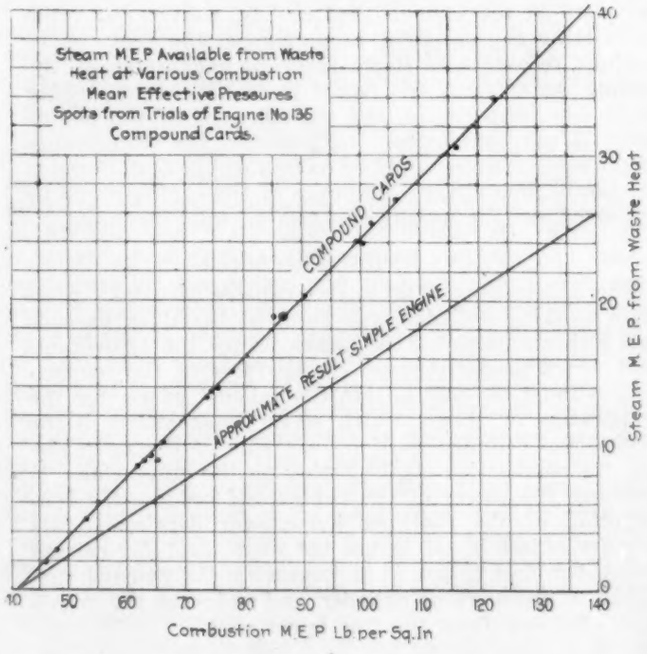


FIG. 4

effective pressure in the cylinder available from the steam, either when used as a simple engine or compounded, plotted against the corresponding combustion pressures. The engine is of the two-stroke type with cylinders 13½ by 22 in. and uses heavy-oil fuel.

The steam thus recovered is a by-product, is limited in amount, and its value depends upon the efficiency of its employment. This is carried out in a logical manner. In place of being expanded in external auxiliary engines, with their thermal and mechanical losses, it is returned to the combustion cylinders of the Still engine, and is expanded on the opposite side of its main piston, one stroke being performed by steam and the other by combustion.

The piston and cylinder walls, preheated by the combustion stroke, are at a higher temperature than the steam when it is admitted and while it is being expanded; there is, therefore, no loss from condensation, and the steam exhausts at a slight superheat above the normal expansion temperature, a condition which is

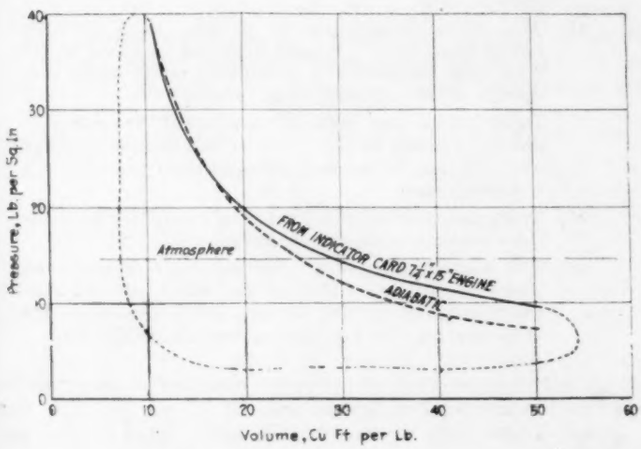


FIG. 5

unobtainable in any form of steam engine without direct loss of energy (See Fig. 5). With an early cut-off it can be expanded economically right out to atmospheric pressure, or below it, and be either recompressed, which is the Stumpf cycle, or exhausted to the condenser. The steam, during expansion, forms an efficient means of cooling the piston. In Fig. 6 the power developed by combustion and steam with the percentage of gain obtained by steam at any combustion mean effective pressure is shown as compared with Figs. 4 and 5.

It may be convenient, at this point, to interpolate a few lines on condensing and compounding, either wholly in the Still engine itself, or in external high-pressure cylinders compounding to low-pressure Still cylinders on the same shaft. These separate high-pressure and intermediate-pressure cylinders will meet special conditions, and have been found of utility where maneuvering or starting in any position is required for single or twin combustion cylinder sets; but a better arrangement in multiple-cylinder sets of Still engines is to use the high-pressure steam in one of the cylinders at the back of the piston, and compound into similar adjacent cylinders. Many variations of these arrangements suggest themselves. Some of these are shown in Fig. 7, where the upper diagram shows how, in a six-cylinder engine, all cylinders can be used with steam entering direct from the boiler

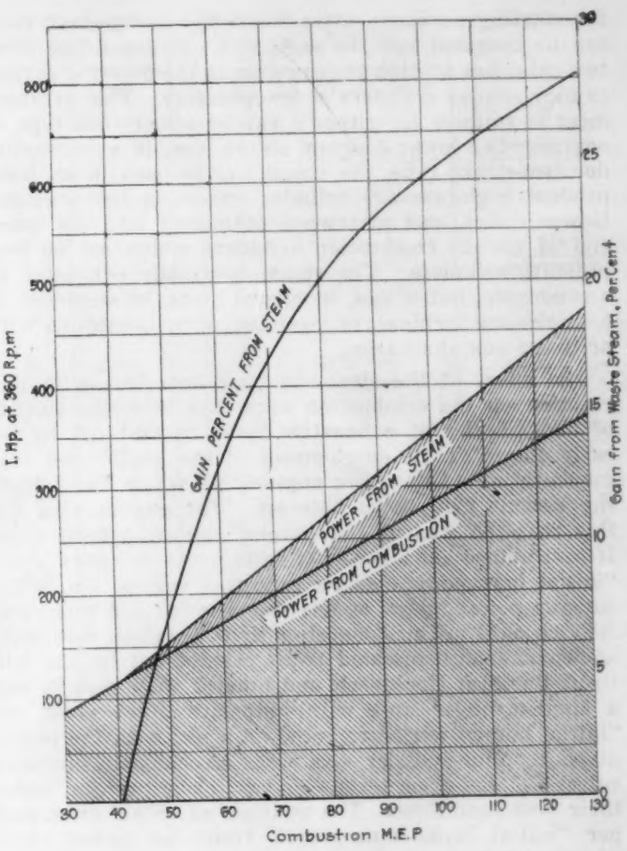

I. Hp. at 360 R.p.m
Gain from Waste Steam, Per Cent
GAIN PER CENT FROM STEAM
POWER FROM STEAM
POWER FROM COMBUSTION
Combustion M.E.P

FIG. 6

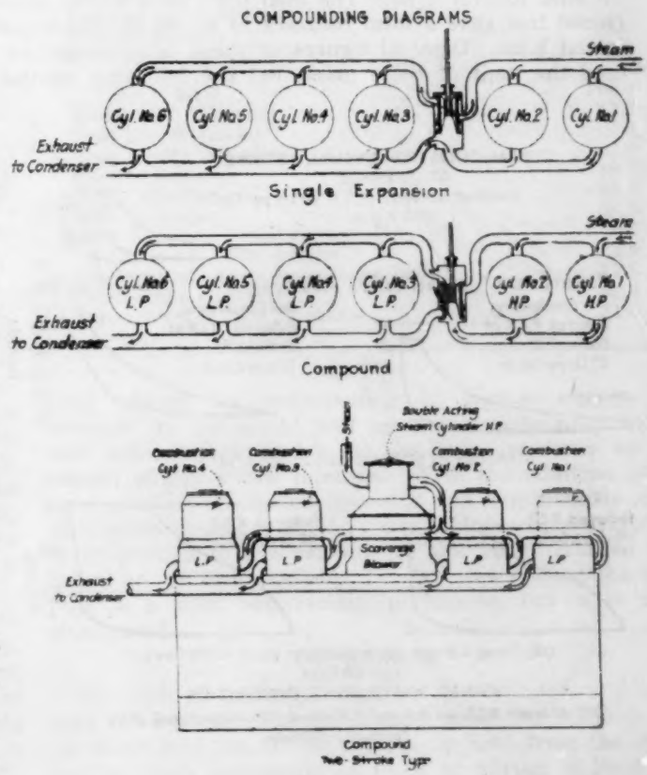


FIG. 7

for starting purposes, after which the change-over valve can be operated and the engine run compounding from two cylinders at high pressure, as in the center diagram, to four similar cylinders at low pressure. This arrangement is suitable for either a two or four-stroke type of engine. The lower diagram shows how, in a four-cylinder two-stroke type, the steam can be used in an independent high-pressure cylinder operating the scavenge blower direct, and afterward exhausted into the lower end of all the combustion cylinders which act as low-pressure cylinders. The steam is usually exhausted to a condenser, but it can, in special cases, be employed in low-pressure turbines, or made use of in connection with producer gas auxiliaries.

The effect of the steam in its cooperation with and reaction on the combustion cycle has been the subject of many series of exhaustive tests, carried out in the early stages of the development of the engine and subsequently on many other engines, of which the following resume may be of interest. The engine used for this research was of four-stroke constant-volume type. It first underwent a series of tests, so as to arrive at its "initial horsepower" as an explosion engine, i.e., without any power added by the steam cycle, and was carefully checked in this connection by comparison with well-known and authenticated trials carried out by the late Prof. Bertram Hopkinson and others. Although it was a single-cylinder unit with automatic inlet-valves, its "initial horsepower" was rated on a par with the power given by four-cylinder sets with mechanically-operated valves deduced from tests over very short periods, under their best conditions. The quantity of steam generated per "initial brake-horsepower" from the jacket alone averaged 3.28 lb. per b.hp.-hr., and from the jacket and exhaust together 6 lb. per b.hp.-hr., this being the average of the whole of the trials over periods varying from 20 min. to over 6 hr. The final 6 hr. of a 7½-hr. continued test gave a total recovery of 6.9 lb. of steam per initial b.hp. Detailed figures of these trials would exceed the limit of these notes, but the following résumé of the results shows the effect of the interaction of the combustion and steam cycles:

(1) The *mean* temperature of the cylinder walls is higher than in ordinary engines; the cooler parts being maintained at a higher, the hotter parts at a lower temperature

(2) The piston is cooler, owing to the expansion of the steam behind it

(3) The heat efficiency of the combustion cycle is augmented owing to the walls being at a higher and constant temperature, and is in proportion to the rise in temperature of the jacket water

(4) Frictional losses are reduced by the higher temperature, and by the steam overcoming the inertia of the reciprocating masses at the lower dead center. In Professor Hopkinson's trials the frictional loss at 65 deg. fahr. was nearly double that when the jacket water was at the maximum obtainable, 212 deg. fahr. In Still's trials the jacket water was at a constant temperature of 320 deg. fahr.

(5) The mechanical efficiency of the whole engine is higher than that obtainable in a normal engine of similar type

(6) The steam, expanding as it does in a cylinder hotter than itself, gives an indicator diagram larger than that theoretically obtainable under ideal conditions in an ordinary steam engine

(7) Twenty-nine per cent of additional brake-horsepower is added to the shaft of the engine, without any increase in the fuel consumption; the steam is not condensed

(8) Forty per cent is added when a condenser is used; the air-pump is separately driven

(9) The initial horsepower due to steam appears as brake-horsepower added to the shaft, all the mechanical losses having already been accounted for in measuring the combustion brake-horsepower

Under normal load, the average mean effective pressure from the combustion stroke was 90 lb. per sq. in. The steam evaporated by the "waste heat" gave 14 lb. per sq. in. m.e.p. on every return stroke. This is equivalent to 90 + 28 = 118 lb. per sq. in. mean effective pressure in a normal four-stroke engine. Under overload, by admitting additional steam generated by the fuel under the boiler, the steam mean effective pressure was therefore equal to 90 + 144 = 234 lb. per sq. in. mean effective pressure in a normal four-stroke engine. Fig. 8 gives examples of combustion and steam indicator diagrams for both normal and overload conditions, taken from a 5 by 5-in. four-stroke type gasoline engine. As the engine had only an automatic inlet-valve, it is interesting to note that with a compression pressure of about 70 lb. per sq. in., the combustion mean effective pressure was over 90 lb. per sq. in. Other diagrams of the combustion side show mean effective pressures as high as 120 lb. per sq. in. on many trials. It is impossible with this compression pressure to obtain such a result except under the heat conditions which exist in a Still cylinder, or by introducing the charge into the cylinder at a pressure above that of the atmosphere.

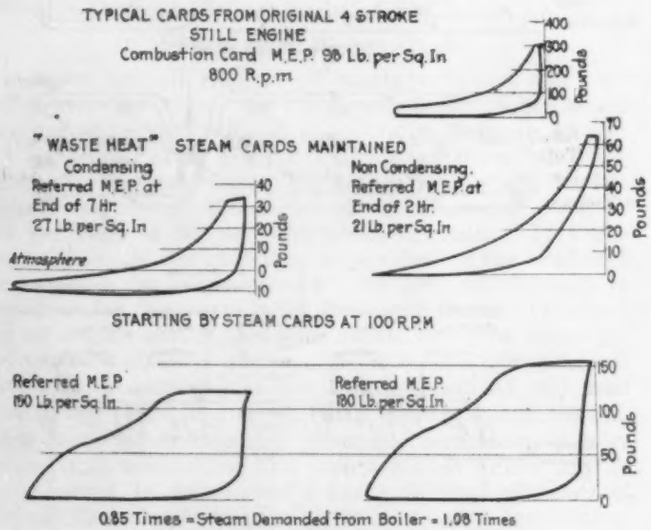


FIG. 8

GAS ENGINES

The first experimental engine constructed was a two-stroke 8-in.-bore engine capable of developing 590 b.hp. from three cylinders at 400 r.p.m. It was a high-speed engine, designed with special regard to obtaining data about the recovery of steam from waste jacket and exhaust heat. It was first operated on 540-B.t.u. town

gas, and subsequently converted for oil fuel. Its efficiency was not high, owing to its being a two-stroke engine with a short stroke, but its consumption per b.hp. was 15 cu. ft. per hr., or 31.3 per cent efficiency, which is a very promising result. The outbreak of war prevented much progress being made in the design and construction of gas engines, but the results achieved give great promise of future development; for, with a combustion indicated efficiency of 36 per cent, radiation of 4 per cent and boiler loss of 10 per cent, there remains 50 per cent for recovery. Allowing 10 per cent efficiency for the steam cycle a gain of 5 per cent is assured, and the total indicated efficiency of the engine will not be less than 41 per cent. If 20 per cent efficiency is obtained from the steam cycle, as appears possible, the total indicated efficiency will be 46 per cent.

Four-stroke engines for gasoline and similar fuels have been built and tested ashore and afloat. Fig. 9 gives an example of a typical fuel-consumption test of a single-cylinder engine used for research work. It was fitted with a condenser and maintained an average vacuum of over 25 in. As the temperature of the whole engine rose to its constant level, the mean effective pressure per stroke given by the steam derived only from the "waste heat" gradually rose from 12 to 14.5 lb. per sq. in.; the fuel consumption of gasoline averaged 0.42

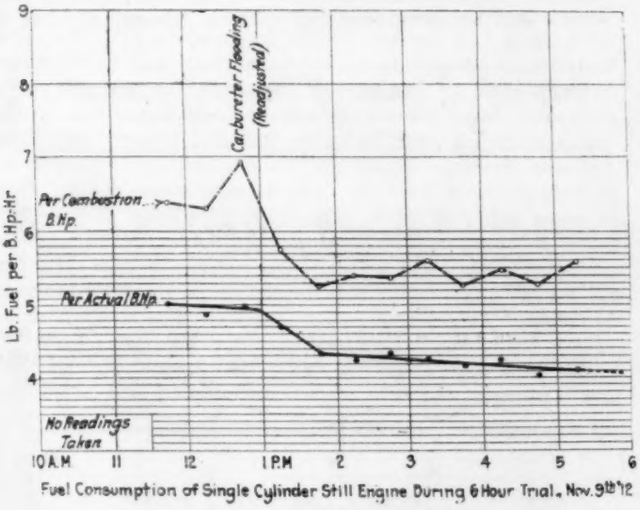


FIG. 9

lb. over the last 4 hr.; but short-period tests under best conditions showed consumptions as low as 0.38 lb., with a brake thermal efficiency of 36 per cent, condenser-pump losses not included. The heat distribution in the same engine when running under conditions to give 33 per cent brake thermal efficiency, pump losses included, is reproduced in Fig. 10. It will be noted that the combustion brake thermal efficiency is 25 per cent; the steam cycle efficiency, 11.8 per cent; and that the increase in brake thermal efficiency due to the steam is 31 per cent.

A three-cylinder set of the marine type, capable of developing on its three small cylinders 12.5 shaft-hp. at 90-lb. combustion mean effective pressure, without power from the steam stroke, at 600 r.p.m., gave on continuous running, 16½ shaft-hp. under "waste heat" conditions, maintaining from the "waste heat" a steady boiler pressure of 100 lb. per sq. in., with suffi-

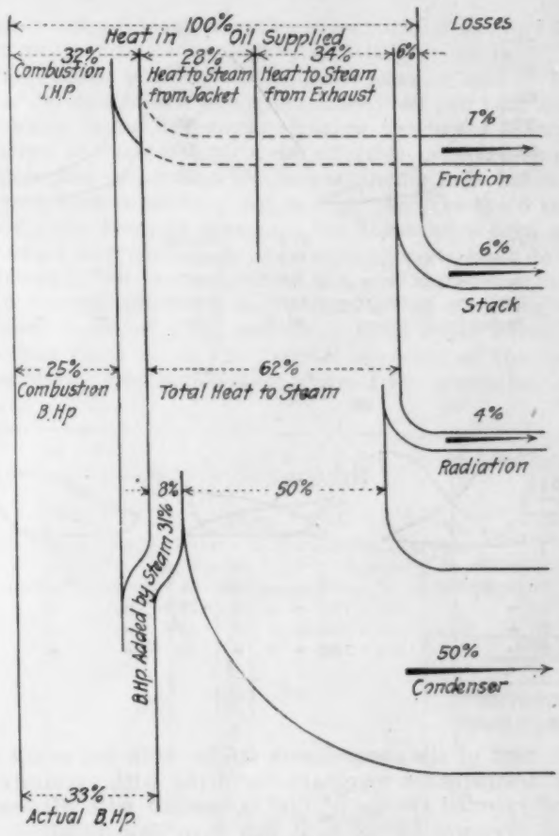


FIG. 10

	Per cent
Heat as combustion initial horsepower	32.0
Heat as combustion brake horsepower	25.0
Heat as combustion friction	7.0
Heat to jacket	28.0
Heat to exhaust	40.0
Total heat	100.0
Mechanical efficiency	83.0
Heat loss to stack	6.0
Heat loss to radiation	4.0
Heat to boiler	68.0
Boiler efficiency	85.0
Heat in steam	58.0
Heat in steam initial horsepower	8.0
Efficiency of steam engine	13.8
Efficiency of steam engine and boiler	11.8
Total brake efficiency	33.0
Percentage of gain by steam	31.0

cient reserve for maneuvering in narrow waters or bringing up. It would pick up very rapidly when ignition recommenced, and bring the boiler pressure up to normal within a few minutes. With the addition of a burner below the boiler, it would run continuously and develop 38 shaft-hp. at 750 r.p.m. Momentary overload in proportion to the capacity of the boiler reached 60 initial-hp. or 51.5 shaft-hp. Under steam alone the engine is a most satisfactory performer, but it is not economical.

OIL ENGINES

The Still oil engine starts with the cylinders and pistons pre-heated. The air-charge, from the moment of its entry into the cylinder, picks up heat from the containing walls and continues to do so during at least 70

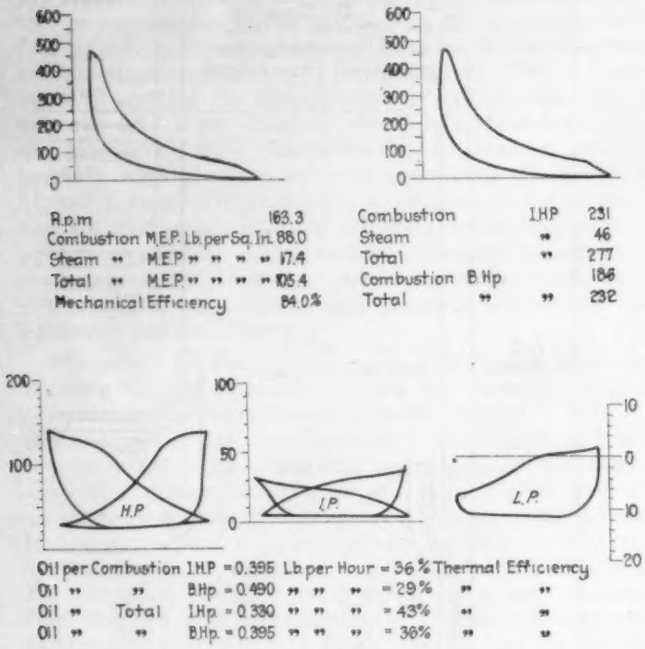

R.p.m 163.3
Combustion M.E.P. Lb. per Sq. In. 88.0
Steam " M.E.P " " " " 17.4
Total " M.E.P " " " " 105.4
Mechanical Efficiency 84.0%
Combustion I.H.P 231
Steam " 46
Total " 277
Combustion B.Hp " 186
Total " " 232
H.P
I.P.
L.P.
Oil per Combustion I.H.P = 0.395 Lb. per Hour = 36% Thermal Efficiency
Oil " " B.Hp = 0.490 " " " = 29% " "
Oil " Total I.Hp = 0.330 " " " = 43% " "
Oil " " B.Hp. = 0.395 " " " = 36% " "

FIG. 11

per cent of the compression stroke, with the result that the temperature necessary for firing with certainty the first injected charge of fuel is reached with a compression pressure 50 per cent less than that required in a Diesel engine. This fact is far-reaching in its importance, for it gives to the designer great elasticity and freedom of application; for a Still heavy-oil engine can be designed for constant pressure or constant volume, or both can be employed in the same engine by correct timing of the fuel injection. It claims for its combustion cycle an efficiency higher than that of the Diesel, less weight and space per horsepower, and for its combined cycle an efficiency not less than 20 per cent higher than any prime mover which uses fuel as its source of heat.

The first engine designed for the use of heavy oil was of the opposed-piston type, 16-in. diameter, 32-in. total stroke, 150 r.p.m., the combustion taking place between the two pistons with the steam generated by the jacket water and exhaust gases expanded at the back of both pistons, the steam passing from the auxiliary boiler through high-pressure and intermediate-pressure cylinders and finally to the Still engine as a low-pressure cylinder, and thence to the condenser. The steam high-pressure and intermediate-pressure cylinders were connected to a prolongation of the main shaft at 90 deg. to the main crank. All auxiliaries were separately driven and thermocouples were connected to all important points in the plant between the combustion space and the base of the stack. The oil was injected by blast air, scavenging was by a fan, pressures were from 0.5 to 1 lb. per sq. in. It was fitted with a brake and flywheel of 4¼ tons weight; from its full power of 300 b.hp. at 160 r.p.m. it will reverse by a single lever from ahead to astern in 10 to 12 sec. Typical combustion and steam indicator diagrams taken from the 16-in. by 32-in. Still heavy-oil engine and tabulated results are given in Fig. 11. The steam increases the power of this engine by 20 per cent, and makes its brake thermal efficiency 36 per cent, including all auxiliaries, which, for a two-stroke single cylinder, the first of its type built for research, is excellent performance.

The fact that these engines are capable of running under steam alone, and under constant temperature conditions, gives a facility and security in carrying out preliminary tests and subsequent accurate research which is not possessed by any other combustion engine. All mechanical adjustments, valve-setting, degree of compression temperatures, etc., can be established at all speeds before any fuel is injected into the main cylinder. This was fully demonstrated in the design and testing of a special engine subsequently constructed to meet special conditions, where the maximum power in minimum space was the main desideratum, conditions not ideal for the highest efficiency. The dimensions of the cylinder were: bore, 13½ in.; stroke, 22 in.; two-stroke cycle, opposed pistons; steam side as for low-pressure cylinder. It forms the basis of a six-cylinder set, two of them using high-pressure steam, which is compounded into the other four as low-pressure cylinders.

The combustion takes place between the pistons, the steam acting on the return stroke at the back of both pistons. After a series of preliminary tests under steam alone, in which data were obtained for the various mechanical adjustments, the scavenging, compression pressures and temperatures, at various speeds, oil was in-

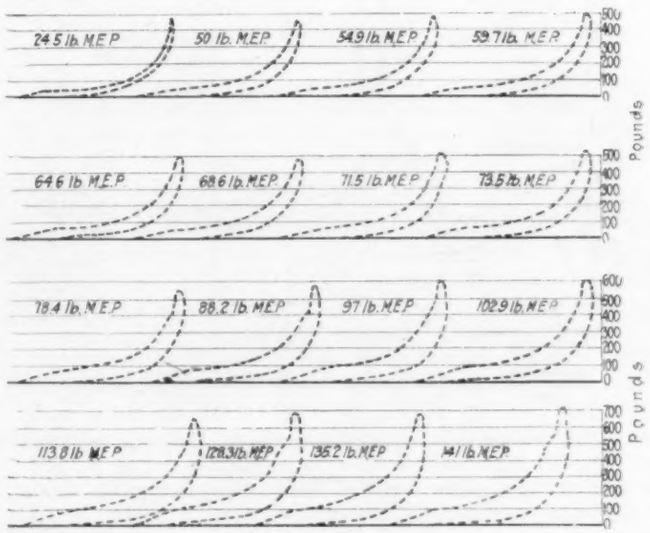
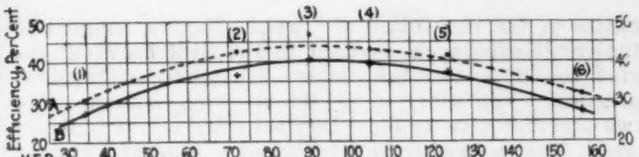


FIG. 12

jected for the first time. The engine fired its first charge without hesitation and completed a series of tests of over 2-hn. continuous running, without adjustment, giving an output by gradually increasing the weight of oil admitted of 100, 150, 200, etc., up to 400 initial-hp., at a maximum speed of 380 r.p.m., for which it was designed. The governing of the engine is best demonstrated by Fig. 12, which gives a set of cards ranging from 24½ to 141 lb. per sq. in. mean effective pressure, produced by the combustion cycle alone. This series of cards, which is reproduced in Fig. 11, can be obtained at a constant or varying speed, progressively, from maximum to minimum, or vice versa, or from extreme to extreme without any interval, the mean effective pressure being varied solely by governing the quan-



	1	2	3	4	5	6
Jacket		7.1	7.8	7.9	9.1	
Exhaust	28.5	38.3	40.1	42.6	42.8	NOT
Stack	13.0	8.5	9.6	6.9	6.6	
Friction	22.4	12.4	12.1 ?	10.7	10.2	RECORDED
Radiation	9.0	4.1	3.0	1.7	2.7	
Power	27.1	29.6	32.4	30.2	28.6	
Total	100.0	100.0	105.0	100.0	100.0	
Waste	28.5	45.4	47.9	50.5	49.4	
Return	0.0	6.9	8.1	8.8	8.4	
Total Power	27.1	36.5	40.5	38.0	37.0	
I.Hp at 360 R.p.m.	97	210	255	300	352	450

Maximum Overload 540 I.Hp

FIG. 13

tity of fuel injected. These cards vary from about 25 to 141 lb. per sq. in. mean effective pressure. The mean effective pressure from the waste heat steam (See Fig. 4) would vary from zero when the combustion mean effective pressure is below 40 lb. per sq. in., up to about 41 lb. per sq. in., with the largest card, giving a total mean effective pressure of 182 lb. per sq. in. It must be remembered that this is a two-stroke engine running at the high speed of 360 r.p.m., and capable of 520 indicated hp. at this mean effective pressure. This unit has been subjected to many long and varied tests by representatives of various Governments, as well as to constant research work under severe conditions. Its best consumption of fuel, which was with Admiralty shale oil, has been as low as 0.302 lb. per b.hp., the scavenging pump not being included, over a test of 1-hr. duration under normal waste-heat conditions. It developed 330 b.hp. for 6 hr. at 360 r.p.m. in a single cylinder, under waste-heat conditions. It will develop 400 b.hp. continuously with added steam, and has developed 540 b.hp. at 380 r.p.m. over short periods. The combustion mean effective pressure was

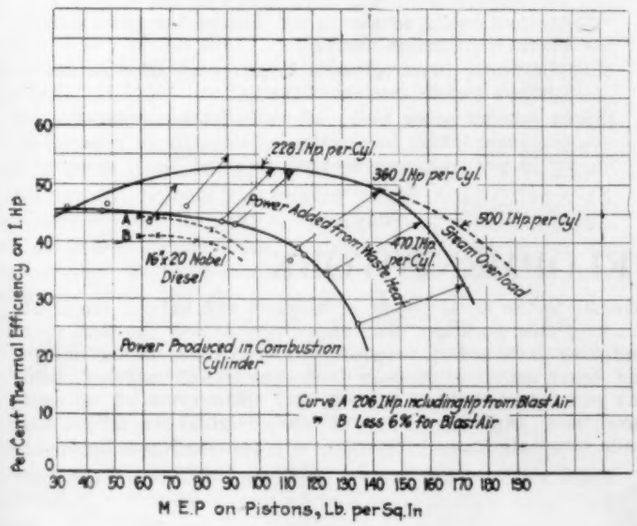

228 I.Hp per Cyl.
360 I.Hp per Cyl.
500 I.Hp per Cyl.
Power Added from Waste Heat
410 I.Hp per Cyl.
Steam Overload
16"x20 Nobel Diesel
Power Produced in Combustion Cylinder
Curve A 206 I.Hp including Hp from Blast Air
" B Less 6% for Blast Air
Per Cent Thermal Efficiency on I.Hp
M E.P on Pistons, Lb. per Sq. In

FIG. 14

128.2 lb.; steam mean effective pressure 57.9 lb.; and the total mean effective pressure 186.6 lb. per sq. in. The thermal brake efficiency from below quarter load to full power is maintained at approximately 40 per cent over the whole range. A curve showing the brake thermal efficiency at various total mean effective pressures, combustion plus steam, and the corresponding heat balances deduced from trials is given in Fig. 13. The third trial shows some error in readings, but these have been left on record and queried in the items which appear to be incorrect. The lower curve of Fig. 14 shows the indicated thermal efficiency of the combustion cycle only at different mean effective pressures. The upper curve on the same basis shows the thermal efficiency of the combined cycle, combustion plus steam from waste heat at

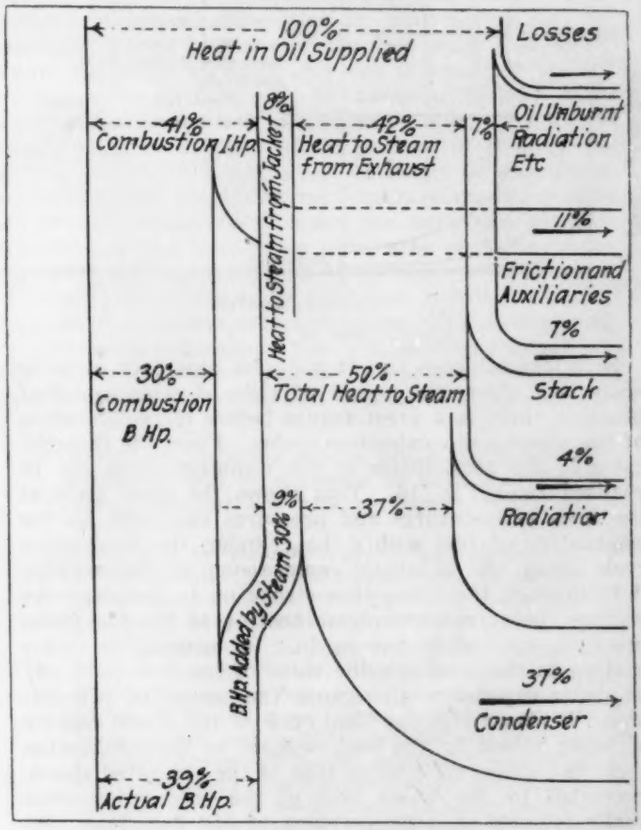


FIG. 15

	Per cent
Heat as combustion initial horsepower	41.0
Heat as combustion brake horsepower	30.0
Heat friction	11.0
Heat to jacket	8.0
Heat to exhaust	51.0
Total heat	100.0
Mechanical efficiency	78.0
Heat lost to stack	7.0
Heat lost to radiation	6.0
Heat to boiler	57.0
Boiler efficiency	81.0
Heat in steam	46.0
Heat in steam initial horsepower	9.0
Efficiency of steam engine	19.6
Efficiency of steam engine and boiler	15.9
Total brake efficiency	39.0
Percentage of gain by steam	30.0

varying loads, as given in Fig. 4. It will be noticed that with any given combustion mean effective pressure not only is the thermal efficiency increased but the power is augmented as shown by the inclined arrows. The area between the two curves represents the gain resulting from the combination. By the addition of steam externally generated, considerable overload is obtained with small loss of efficiency. Curves *A* and *B* from the trials of a considerably larger two-stroke Nobel Diesel engine are added for comparison.

The heat distribution of the 13½ by 22-in. Still heavy-oil engine, including all auxiliaries, is shown in Fig. 15 and is tabulated underneath the diagram on page 433.

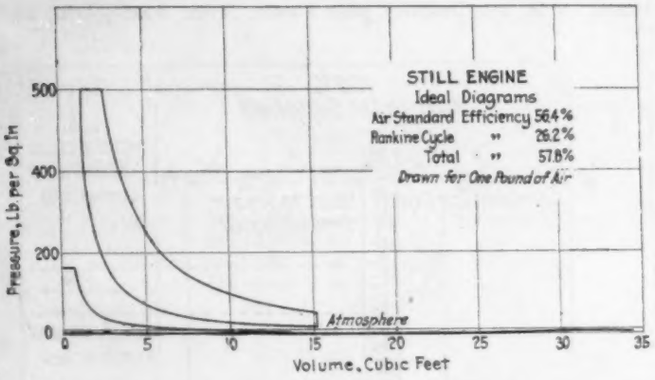


FIG. 16

Sufficient evidence has, it is hoped, now been given to show that, from the points of view of science and of practice, there is a great future before the combination of the steam and combustion cycles. From the theoretical side the possibilities of the combined cycle can be realized from Fig. 16. This shows the ideal cycle at the high temperatures and pressures realizable by the combustion of fuel within the cylinder, the combustion cycle being (*a*) adiabatic compression of the working fluid through the full piston stroke up to the clearance volume; (*b*) constant volume heating to the maximum pressure, say 600 lb. per sq. in.; (*c*) constant pressure heating to the total calorific value of the fuel; and (*d*) adiabatic expansion throughout the stroke to full volume. It shows also the ideal cycle of the steam capable of being raised by the heat rejected in the combustion cycle, the steam cycle being that of the saturated steam, generated by the waste heat of the combustion cycle finally rejected at a temperature of 150 deg. fahr., expanded from 165 lb. per sq. in. absolute, by the Rankine cycle, down to 5 lb. per sq. in. absolute pressure. One cycle is in accordance with the air standard of the Committee of the Institution of Civil Engineers, adapted to the combustion cycle as used in the Still heavy-oil engine, partly at constant volume and partly at constant pressure. The other is by the Rankine method. The two together give an ideal thermal efficiency of 67.8 per cent. That a two-stroke high-speed engine of an early type, not designed specially for efficiency, should already have reached an actual efficiency of 47 per cent, that is to say, an efficiency ratio of 70 per cent, warrants the assurance that still higher efficiencies will be obtained in later designs, where full advantage is taken of lessons already learned with regard to clearances, compounding, etc., which are being embodied in designs now under construction. But science and practice, like capital and labor, must work hand in hand. It is satisfactory, therefore, to state that in practice the Still engine can claim that it has carried out completely the objects of its inventor and corroborated and confirmed the principles on which he has worked.

The advantages of the Still engine can be summarized as follows:

(1) The higher mean temperature of the engine makes the combustion cycle more effective and more reliable in starting and in running
(2) The mechanical stresses due to heat are reduced
(3) The steam generated by the heat rejected by the combustion cycle
  (*a*) Augments the power of the engine without increasing the consumption of fuel; (*b*) cools the piston; (*c*) reduces the mechanical losses of the engine; (*d*) is used under exceptionally favorable conditions, since it absorbs heat during expansion; (*e*) suffers no condensation loss in the working cylinder; (*f*) warms the engine before starting, so that no sudden temperature changes occur in any part; (*g*) starts the engine against load if necessary; and (*h*) enables maneuvering at any speed from nothing to maximum and for any period
(4) Starting is unaffected by atmospheric conditions
(5) Power at normal loads is developed by combustion and steam from waste heat alone, with an efficiency at least 25 per cent above any known combustion engine of similar proportions
(6) Since the steam raised by the waste heat is more than enough to overcome the mechanical losses of the engine, the brake horsepower of the engine is at least equal to the initial horsepower produced by the combustion stroke
(7) Additional steam gives a large range of overload without serious loss in efficiency
(8) In engines using heavy oil as fuel the compression pressures which insure the ignition can be reduced by 50 per cent, as compared with the Diesel system

ARMY BALLOON DEVELOPMENT WORK

THE principal activity of the United States Army Balloon School at Fort Omaha, Neb., is along experimental and research lines. This work is at present in the process of expansion and has not yet been thoroughly organized due to lack of engineering personnel. Efforts are being made to secure the necessary personnel which is made possible through allotments recently made. The work assigned to the station consists in the development of balloons and balloon material. Much of this work has been under way during the past year and very satisfactory progress has been made in the design and construction of balloon instruments and winches, field gas generators, balloon fabrics, etc. New types of balloons have been experimented with and original investigations made into ballooning problems.—Air Service News Letter.

Design Factors for Airplane Radiators

By SAMUEL R. PARSONS[1] *(Non-Member)*

AERONAUTIC MEETING PAPER

THIS paper presents in brief form the more important results of the investigation of airplane radiators at the Bureau of Standards. Approximate empirical equations and constants are given wherever possible, but all discussion of experimental methods is omitted. The work is treated in detail, with descriptions of the experimental methods and mathematical treatment, in a series of reports, written by various members of the staff, published by the National Advisory Committee for Aeronautics.

The fundamental requirement for a radiator for an airplane engine is that it shall maintain the temperature of the water in the cylinder jackets within a limited range. In so doing it must dissipate heat under conditions that vary between wide limits. The speed of the airplane and consequently the rate at which air passes through the radiator are much greater for level flight at full throttle than for maximum rate of climb. Atmospheric temperatures vary widely between summer and winter, and between the ground and great altitudes; also, the density of the air falls off rapidly with altitude, being about one-half as great at 20,000 ft. as at the ground. If a supercharging engine is used, the maximum speed of level flight may be considerably higher at great altitudes than near the ground.

With the use of supercharging engines, the most severe conditions for the radiator may occur at great altitudes. Since in general the most severe conditions for the radiator are those of climb at the maximum rate near the ground, the radiator is usually designed for this condition and provided with some means for shuttering, to control its cooling capacity when under less severe conditions. But while a capacity for dissipating heat to the atmosphere is the primary requirement of the radiator, it becomes necessary in aeronautic work to give very careful consideration to the effects of the radiator on the airplane. First, it adds somewhat to the weight to be carried; second, it adds considerably to the air resistance of the airplane. That is, more power is required to drive the plane than would be needed if it could be operated without a radiator. The force required to push the radiator through the air, called its head resistance, is considerable at high speeds. For many of the types of radiator submitted for aeronautic use it is so great that if an airplane were driven at 120 m.p.h., a radiator large enough to cool the engine would absorb from 12 to 15 per cent of its power. The radiator causes absorption of power in two ways, in carrying its weight and in overcoming its head resistance. It also has other adverse effects on the plane, among which are (*a*) obstruction of the pilot's view, (*b*) modifications in internal construction of the fuselage to accommodate the mounting of the radiator, and (*c*), in military machines, liability to injury from hostile fire.

It is evident that while the best conditions for heat transfer require that the air shall flow rapidly past the cooling surfaces, this condition gives rise to high head resistance. The problem of radiator design thus becomes one of obtaining a maximum rate of heat transfer with a minimum absorption of power. The fundamental criterion for a good radiator is that it shall dissipate heat at the required rate with a minimum absorption of power. Various devices have been suggested, such as using the under side of the wing for the cooling surface or building the struts and other parts of the airplane with double walls and passing water through the spaces formed. While such construction might furnish heat transfer with no great increase in head resistance, it involves mechanical difficulties in construction and is essentially heavy, because, of the two walls that must contain the water streams, only one is available for effective cooling surface and, furthermore, to keep frictional resistance within reasonable limits, the water streams must be fairly thick on account of their great length. The construction would obviously be unsuitable for military use, because of its vulnerability. Such surface would probably be of about the same effectiveness as a dissipater of heat as an equal area of cooling surface made up into a good form of radiator.

The most important quantities that describe the performance of a radiator are given below. The units named are chosen for convenience and will be used throughout unless other units are specified. It will be noted that all quantities are reduced to unit frontal area of radiator core.

(1) Heat transfer is the rate at which heat is dissipated. It will be expressed in horsepower per square foot, or kilowatts per square meter, of frontal area

(2) Air flow is the mass flow of air through the core of the radiator. It will be expressed in pounds of air per second per square foot, or grams per second per square centimeter, of frontal area

(3) Head resistance is the force required to push the radiator through the air. It will be expressed in pounds per square foot, or kilograms per square meter, of frontal area. Head resistance of the radiator core is to be distinguished from head resistance "chargeable to the radiator," which includes any part of the resistance of the entire plane that may be due to modifications in design necessitated by the presence of the radiator. That is, head resistance chargeable to the radiator is the difference between the resistance of the entire plane and the resistance that it might have had if it could have been designed without a radiator

(4) Weight is expressed in pounds per square foot, or kilograms per square meter, of frontal area, including the water contained in the core

(5) The power absorbed is that used in overcoming head resistance and in lifting and sustaining the weight. It will be expressed in horsepower per square foot, or kilowatts per square meter, of frontal area. A distinction is to be made between the power absorbed by the radiator core and the power absorbed chargeable to the radiator, similar to that stated for head resistance

(6) The figure of merit is the ratio of the rate of dissipation of heat to the power absorbed, when both are expressed in the same units. A high figure of merit is the fundamental criterion for a good radiator

[1] Bureau of Standards, Washington.

In considering the performance of the radiator, it is convenient to divide the possible positions in which it can be mounted on the plane into three classes (*a*) unobstructed, in which the flow of air through and around the radiator is unaffected by other parts of the plane; (*b*) obstructed, in which the flow of air through the radiator is reduced by the effects of other parts of the plane; and (*c*) slipstream positions, in which the blast from the propeller blows over the radiator. It will be noted that slipstream positions include both those that would be obstructed, except for the propeller, and those that would be unobstructed.

Heat Transfer

Heat transfer depends upon (*a*) the temperature difference between the air and the water; (*b*) the rate of flow of air through the air passages, and (*c*) the rate of flow of water through the water passages.

For the temperatures involved in the use of water-cooled radiators, heat transfer can be assumed to be proportional to the mean temperature difference between the air and the water. For practical purposes it can be regarded as proportional to the difference between the average of the temperatures of the water at entrance and exit and the temperature of the entering air. For a given temperature difference between air and water, the heat transfer increases with the rate of water flow, when the rate is low but, at the rates commonly used in aeronautic practice, heat transfer is not far from the maximum that can be obtained with change in water flow and can be regarded as practically independent of that rate. If for ordinary types of cellular radiators not more than 5 in. (13 cm.) deep in the direction of air flow, the water flow is above 2 gal. per min. per ft. width[2] of core per in. depth of core, or 1.63 cu. cm. per sec. per cm. width of core per cm. depth of core, the heat transfer can be regarded as independent of changes in the rate of water flow. In the following discussion it will be assumed that the rate of water flow is maintained high enough that its effects can be neglected.

For a given temperature difference and a rate of water flow sufficiently high to make the above assumption valid; the variation of heat transfer with air flow can be represented empirically by the equation

$$H = c\ T\ M^n$$ where

H = the heat transfer
T = the difference between mean water temperature and the temperature of the entering air
M = the mass flow of air
c = a constant
n = a constant

For the English units, if T is taken as 100 deg. fahr., c ranges from 6.4 to 15.0 for various types of core. For the metric units, if T is taken as 50 deg. cent., the range is from 80 to 200. The value of n ranges from 0.6 for types with large amounts of "fin" or indirect cooling surface, surface not backed by flowing water, to 0.9 or even unity for types with only direct cooling surface.

Air Flow

The air flow through the radiator, the mass flow, is ordinarily proportional to the speed of the airplane and to the density of the air. For unobstructed positions, positions such that the flow of air through and around the radiator is practically unaffected by other parts of the airplane, the mass flow of air can be computed from the equation

$$M = k \rho V$$ where

M = the air flow in pounds per second per square foot of frontal area, or grams per second per square centimeter
V = the airplane speed in feet per second, or centimeters per second
ρ = the air density in pounds per cubic foot, or in grams per cubic centimeter
k = a constant for each type of radiator, but, since the constant k is dimensionless, any other consistent set of units might be used.

The constant k is called the "mass-flow constant," and is equal to the fractional part of the air approaching the radiator that actually passes through it, or unity minus the fraction that is deflected around it. This mass-flow constant is a complicated function of the geometrical characteristics of the radiator, but for the more usual types with cellular construction it ranges between 0.60 and 0.85. For radiators of the "fin-and-tube" type, the mass-flow constant may be much less, and certain peculiar types that produce a whistling sound when in an air stream have no mass-flow constant, because the air flow is not proportional to the airplane speed. Both of these types, however, are unsuitable for general aeronautic use, because of excessive head resistance.

When the radiator is in an obstructed position, as in the nose of the fuselage or the wing, the air flow through the core is in general much less than it would be if the radiator were unobstructed. Because of the devious path that must be followed by air that enters the fuselage through a nose radiator, a large portion of the air will be brought up to a speed approaching that of the airplane before finding its way out from the fuselage. This acquisition of speed is accompanied by a considerable absorption of power, and builds up a considerable air pressure in front of the radiator. Furthermore, air escaping from the sides of the fuselage interferes seriously with the flow of air past the sides, which might otherwise be fairly well streamlined. These considerations show that a radiator in the nose of the fuselage can be expected to increase greatly the resistance of the fuselage, and to give only a small flow of air through the radiator. For positions in the nose of the fuselage the mass-flow constant probably ranges between 0.3 and 0.7, depending upon the type of core and the provision made for letting the air out of the fuselage after it has entered through the radiator.

In considering a radiator mounted in the wing it should be borne in mind that, with wings of the present types, the air flow cannot be large, for, while the wing is designed to cause a difference in pressure between the upper and lower surfaces, it is not designed to maintain such a pressure difference when air is flowing from one surface to the other. The region of low pressure on the upper side of the wing occurs only near the surface, and even a small amount of air flowing up through the wing, in the case of a wing radiator, will bring the pressure in this region nearly up to that on the under side of the wing, so that only a very small air flow can be maintained. For a radiator mounted in the wing, the mass-flow constant is probably between 0.05 and 0.25.

When the radiator is either wholly or partly in the slipstream of the propeller, the air flow and consequently the heat transfer are somewhat greater than they would otherwise be for the same position. The effect of the slipstream evidently varies with different positions and

[2] A dimension perpendicular to the general directions of both water flow and air flow.

with different types of airplane, but it is usually assumed that the speed of the air stream relative to the radiator is 20 to 25 per cent greater in the slipstream than outside of it. The relative increase in air flow through the radiator is probably somewhat less than the relative increase in speed past the radiator, because in the slipstream the air does not strike the radiator in a direction normal to its face.

Head Resistance

The head resistance of the radiator can be assumed, for usual purposes, proportional to the square of the flying speed and to the density of the air. For unobstructed positions it may be represented by the equation

$$R = b \rho V^2 \text{ where}$$

R = the head resistance in pounds per square foot, or kilograms per square meter, of frontal area
V = the airplane speed in miles per hour, or in meters per second
ρ = the air density in pounds per cubic foot, or grams per cubic centimeter
b = a constant for each type of radiator.

The value of b ranges between very wide limits. If the English units are used, for cellular radiators with straight-sided air tubes, it ranges from 0.0009 for cores with very large free area to 0.0023 for types with very small free area; for fin-and-tube radiators, unless very open, it exceeds 0.0020; and for irregular types with turbulence vanes it may run as high as 0.0026. The corresponding values for the metric units are respectively 1.4, 3.5, 3.1 and 4.0.

When the radiator is placed in the nose of the fuselage, the head resistance chargeable to the radiator, meaning the difference between the head resistance of the complete airplane and the resistance that it might have had if it could have been designed without a radiator, is in general very large and, for a given flying speed, the head resistance chargeable to the radiator increases with increase in air flow. It is considerably greater for a radiator placed in the nose of the fuselage than when the nose of the fuselage is streamlined and a radiator of equivalent cooling capacity is placed in an unobstructed position. A radiator placed in the wing increases, in general, the resistance, or drag, of the wing, but the increase is not large and there may even be a decrease at certain angles of attack. The radiator, unless shuttered, will inevitably decrease the lifting power of the wing.

If the radiator is placed in the slipstream, the head resistance chargeable to it is probably approximately equal to what it would be if the propeller could be removed and the airplane driven by some other means at such a speed as would give the same speed of air relative to the radiator. If this is true, the assumption that the speed of the slipstream relative to the radiator is from 20 to 25 per cent greater than the flying speed would apply to head resistance as well as it does to air flow. Since head resistance varies as the square of the speed, an increase of 20 per cent in speed results in an increase of 44 per cent in resistance. The effect of the swirl of the slipstream is similar to that of yawing the radiator, which is to increase the head resistance for unobstructed positions and for positions that would be unobstructed but for the propeller. For positions that would be obstructed without the propeller, as in the nose of the fuselage, the effect of the swirl of the slipstream is to make the air flow somewhat less than it would be if there were no swirl and, since for such positions the head resistance chargeable to the radiator increases with increased air flow, the effect of the swirl probably compensates to a slight extent for the effect of the increased speed of air due to the propeller.

Power Absorbed

Since in this paper the power absorbed is reduced to unit frontal area, the statements apply to the power absorbed by a given radiator, rather than to the power absorbed in cooling a given engine. The power absorbed is composed of two parts: that due to head resistance and that due to weight. Since the head resistance varies approximately as the square of the flying speed, and the power can be measured by the product of a force and a velocity, the power absorbed due to head resistance varies approximately as the cube of the speed. Since, however, the weight is sustained by a "lift" on the wings, which is a constant and equal to the weight, and since this is accompanied by a "drag" that is proportional to the lift for a given angle of attack, the power absorbed due to weight is more nearly proportional to the first power of the speed, and is dependent upon the lift/drag ratio of the airplane. The power absorbed can be computed from the equation

$$P = k\left(R + \frac{w}{r}\right)V \text{ where}$$

P = the power absorbed in horsepower per square foot, or kilowatts per square meter, of frontal area
R = the head resistance in pounds per square foot, or kilograms per square meter, of frontal area
w = the weight of the core and the contained water in pounds per square foot, or kilograms per square meter, of frontal area
r = the lift/drag ratio of the airplane
V = the flying speed in miles per hour, or meters per second
k = a conversion factor which is 0.00267 for the English units and 0.00980 for the metric units.

For speeds below 60 m.p.h., or 30 meters per sec., the weight is of considerable importance in comparison with the head resistance, but as the speed increases it becomes relatively less important and for speeds as high as 100 m.p.h., or 45 meters per sec., the difference in weight between one radiator and another is of but small importance.

The figure of merit, being the ratio of heat transfer to the power absorbed, is dependent upon all the factors that influence those quantities. It decreases with increase of speed, falling off very rapidly at the lower speeds and but slowly at the high speeds. It is given by the equation

$$F = \frac{H}{P} \text{ where}$$

F = the figure of merit
H = the heat transfer and
P = the power absorbed, both measured in the same units

Special Features of Core Design

For unobstructed positions the total heat transfer, air flow, head resistance and power absorbed can be taken as proportional to the frontal area of the core, with small corrections to the head resistance and the power absorbed values on account of headers and connections. The figure of merit is of course independent of size, except as affected by these corrections. When the radiator is in an obstructed position, no simple statement can be made in regard to the effect of its size, because the influence of the surrounding parts of the structure

may be very great. This is discussed later under the heading Effects of Position on the Airplane.

Increasing the depth, the dimension parallel to the direction of the air flow of a particular type of radiator increases its heat transfer for a given air flow by increasing the amount of cooling surface, but the added surface becomes less and less effective as the depth is increased, on account of the rise in temperature of the air in its passage through the radiator and the consequent decrease in temperature difference between the air and the water. Furthermore, the resistance to air flow increases with the depth, so that the air flow falls off for a given flying speed. An increase in depth is accompanied by an increase in head resistance, weight and power absorbed, but at the smaller depths the disadvantage of the increased absorption of power is less than the advantage of the increased heat transfer, and the figure of merit rises to a maximum at a certain depth which varies with different airplane speeds.

Estimates based on empirical equations indicate that the most efficient depths for certain general types of radiators are given in Table 1.

TABLE 1.—MOST EFFICIENT RADIATOR DEPTHS FOR UNOBSTRUCTED POSITIONS

Type of Radiator	Airplane Speed, m. p. h.	Depth, in.
¼-in. square cell	60	5
	100	8 to 10
	130	9 to 13
Flat plate, plates about $\frac{1}{16}$ in. thick		
½-in. pitch[3]	60	8
	90	10 to 12
	120	12 to 15
¼-in. pitch[3]	60	6
	90	7
	120	7 to 9

[3]Measured across the face of the radiator, from center to center of the plates.

The change in the figure of merit with any change in the depth is much less rapid at high than at low speeds and, if considerations of construction make a small frontal area very desirable, the depth can be considerably increased over the optimum value, for use at the higher speeds, without greatly reducing the efficiency.

The free area is the fractional part of the frontal area of the core that is open for the passage of air. For use in unobstructed positions a large free area is desirable to increase the air flow and decrease the head resistance, and should be sacrificed only for the sake of compactness of the radiator. Care taken in making the water tubes as narrow as is compatible with sufficient strength and space for water flow is repaid by an increased radiator efficiency.

For use in unobstructed positions, it is important that the air passages should be straight and as smooth as is practicable, to facilitate the air flow and reduce the head resistance. Projections, indentations and holes in the sides of the air tubes add greatly to the head resistance without causing a corresponding increase in heat transfer. The slight advantage of saving in metal gained by punching holes in the indirect cooling surfaces is more than outweighed by an increased head resistance and an increase in the turbulence of the air, which, although it might be thought to increase the heat transfer, causes such a reduction in the air flow that the heat transfer for a given flying speed may be actually reduced.

In general, all surfaces past which air flows should be continuous from the front to the rear of the radiator, to give a maximum of effective cooling surface with a minimum air resistance. It is important for the designer to bear in mind that skin friction between air and the surfaces past which it flows is only a part of the head resistance, and that the losses at the entrance and the exit of the air tubes are very great, amounting sometimes to as much as one-half of the total head resistance. Smoothness of cooling surfaces is desirable and reasonable cleanness of surface is essential. A highly-polished surface has been shown to dissipate 15 per cent more heat for given conditions of air flow and temperature than an ordinarily smooth surface; and a surface lightly smoked has been shown to dissipate 10 per cent less heat than a surface only ordinarily smooth but clean. Corresponding but less noticeable effects have been observed on air flow and head resistance, and it is clearly shown that the efficiency of a radiator can be increased by polishing the cooling surfaces; but if the surfaces are kept reasonably clean, the differences in smoothness between surfaces usually encountered in actual practice are not great enough to show any very marked difference in radiator performance.

Measurements of temperature and pressure in the air tubes of a radiator indicate that the air flow is turbulent, at the speeds encountered in practice, for the entire length of the tubes. If a radiator of cellular type is to be used in unobstructed positions, the addition of spiral vanes or other devices which might be thought to increase turbulence is detrimental to the efficiency of the radiator. Such devices may appear to give an increased heat transfer for a given air flow because of the increase in the amount of cooling surface, but in tests of a large number of widely differing types of radiator there has been very little indication that the heat transfer per unit cooling surface is increased, and in some cases it is decreased. If a comparison is made at a definite flying speed, the addition of turbulence devices greatly reduces the air flow, and any tendency toward an increase in heat transfer per unit frontal area is often, if not always, overbalanced by the effect of the reduced air flow. Turbulence devices greatly increase head resistance.

The indirect cooling surface is the cooling surface not backed by flowing water. Indirect surfaces, or "fins," can be used to good advantage if proper attention is given to thermal conductivity, thermal contact between the indirect surface and the water-tube walls and shortness of the distances that heat must be conducted through the fins. The use of indirect cooling surface amounts to closing a water tube by pressing the walls close together, or to substituting a single sheet of metal for a water tube. The advantages are in saving the weight of water contained in the tube and, in the latter case, the weight of one wall, while allowing relatively large free area of core for a given area of cooling surface. The disadvantage arises from the fact that heat must be transferred by metallic conduction for a distance along the fins and away from the water-tube walls, before being dissipated from the surface to the air. Since heat can be conducted along the fins only with a drop in temperature, the temperature difference between metal and air is less for fins than for direct surface and decreases with distance from the sources of heat. Not only is thermal conductivity important in the fins, but thermal contact between the fins and the water-tube walls is very important, although in many types of radiator it appears to have received but little attention. Indirect surfaces may touch the water-tube walls at a number of points and yet make very poor thermal contact. They should be soldered to the water-

tube walls at every practical point, except where the metal of the fin is continuous with that of the wall.

If the efficiency of indirect cooling surface is defined as the ratio of its rate of heat transfer to that of an equal area of direct surface under the same conditions of temperature and air flow, then for the type of indirect surface commonly employed in square-cell radiators, where the fin is continuous with the water-tube wall on one side and its length in the direction parallel to the wall is large in comparison with its width in the direction perpendicular to the wall, the thickness of fin that will result in any given efficiency is directly proportional to the square of the width, to a power of the air flow that is approximately 0.8, and inversely proportional to the conductivity of the metal if formed by folding the metal over, the thickness of the fin includes both thicknesses of metal.

Table 2 shows the approximate thicknesses of fin that will give efficiencies of 90 and 95 per cent, with different widths. This table is computed for a fin long in the direction parallel to the tube wall, and narrow, of rectangular form, soldered or continuous with the walls on both edges. If only one edge is in good contact, the thickness must be multiplied by 4.

TABLE 2.—FIN THICKNESS FOR DIFFERENT WIDTHS, SPEEDS AND EFFICIENCIES

	Copper				Brass			
Efficiency, per cent.	90		95		90		95	
Speed, m.p.h.	150	60	150	60	150	60	150	60
Width, in.								
0.250	0.0017	0.0008	0.0038	0.0018	0063	0.0030	0.013	0.0064
0.375	0.0039	0.0019	0.0085	0.0040	0.0140	0.0066	0.030	0.0140
0.500	0.0069	0.0033	0.0150	0.0073	0.0250	0.0120	0.053	0.0260
1.000	0.0280	0.0130	0.0610	0.0290	0.0990	0.0480	0.213	0.1030

If one-half of the cooling surface of a radiator is indirect, with an efficiency of 90 per cent, the total heat transfer of the radiator is only 5 per cent less than it would be if the efficiency of the indirect surface were 100 per cent.

The composition of the metal used for direct cooling surface backed by flowing water is unimportant from the standpoint of heat conduction, since almost any metal will conduct heat through the thin walls of the water tubes, with very little drop in temperature, as rapidly as it can be dissipated from the surface. The choice of metal should be based upon other considerations than thermal conductivity. For indirect cooling surface, however, the conductivity of the metal is important, as is shown in Table 2.

The special types of core include radiators made of water tubes in the form of flat hollow plates placed edgewise to the air stream and with no indirect cooling surface. This type has been shown to be markedly superior in respect to heat dissipation per horsepower absorbed, over the ordinary types of cellular radiator for use in unobstructed positions on planes flying at the higher speeds. The mechanical weakness of the flat-plate type is an inherent disadvantage, but one that can doubtless be overcome. Radiators of the fin-and-tube type show very high head resistance and low air flow; for this reason they are unsuited for general aeronautic use.

Tests have been made on certain special types of core, made with water tubes deep in the direction of air flow, and narrow, placed side by side, one behind another, with spaces between consecutive rows in each direction. These types produce a shrill whistling sound when in an air stream of more than about 30 m.p.h., or 15 meters per sec., and show irregular properties. That is, the air flow through the core is not proportional to the flying speed and the head resistance is not proportional to the square of the speed. These types show very high heat transfer for a given air flow, but very low air flow for a given flying speed. They show also a very high head resistance, with the result that the heat transfer for a given flying speed is in general not high and the figure of merit is very low. The whistling types are not suitable for aeronautic use.

EFFECTS OF POSITION ON THE AIRPLANE

The important effects of the location of the radiator on the airplane have already been stated in the first paragraph on page 438. Such quantitative results as have been obtained to date are given there. Attention is called to the three classes of positions already defined. The unobstructed positions have the following advantages:

(1) Except for the effects of the slipstream, the air flow through the core, and consequently the heat transfer, are greater for unobstructed than for obstructed positions

(2) The head resistance chargeable to the radiator is considerably less for unobstructed positions than for positions in the nose of the fuselage, in the wing or inside of the fuselage. The effect of the slipstream is to increase the head resistance of a radiator that would otherwise be unobsfructed

(3) Since air flow is greater in unobstructed than in obstructed positions and, therefore, heat transfer per unit frontal area is greater, it follows that the weight of a radiator may be less for a given cooling capacity when in an unobstructed than when in an obstructed position

(4) With reduction both in weight and in head resistance chargeable to the radiator, the power absorbed chargeable to the radiator is reduced by placing the radiator in an unobstructed position, rather than in an obstructed position

(5) With both increase in heat transfer and decrease in power absorbed, the figure of merit of an unobstructed radiator is considerably greater than that of the same type of radiator in an obstructed position

The location of the radiator in the nose of the fuselage is objectionable because of very large absorption of power for a given cooling capacity. Not only is the resistance of the airplane much greater with a nose radiator than with the nose properly streamlined and an unobstructed radiator of equivalent cooling capacity added, but the air flow through the core is so low that with engines of the higher powers it becomes necessary to enlarge the fuselage to accommodate a nose radiator of sufficient size to cool the engine.

The performance of a radiator in the wing has not been thoroughly investigated because of experimental difficulties, but enough data are available to show that the air flow, and consequently the heat transfer, are very low for a given flying speed, while the effect on the wing as such can only be detrimental.

The effect of the propeller slipstream is to increase to some extent the air flow and heat transfer of the radiator. No specific statement can yet be made in regard to its effect on the head resistance of radiators in obstructed positions.

The information at present available on the effects of different positions on the airplane points to the following

statements regarding the types of core suitable for different positions:

(1) For unobstructed positions, the radiator should be characterized by straight smooth air passages and low head resistance

(2) For positions in the nose of the fuselage, the head resistance chargeable to the radiator increases, for a given frontal area, with increase in air flow. The most suitable type of radiator will be one that gives a high rate of heat transfer with a low air flow. This consideration leads to the use of a compact type with a large amount of cooling surface per unit frontal area and, since the head resistance chargeable to the radiator does not increase with the head resistance of the core, cooling surface can be added, even in the form of spiral vanes or other turbulence devices, without serious detriment. Whether the turbulence devices really increase turbulence and thereby increase the heat transfer more than would be done by an equal amount of straight and smooth surface, is a question that needs further study

(3) For positions in the wing, the requirements are probably similar to those for positions in the nose of the fuselage

Flight Control of Cooling Capacity

Among the more important methods proposed for the control of the cooling capacity of the radiator in flight are the following:

(1) The use of detachable sections is good for seasonal corrections such as summer and winter conditions, and for change from one latitude to another

(2) The construction of retractable types that allow withdrawing the radiator or a portion of it into the fuselage when its full cooling capacity is not needed, is one of the best methods of control from the standpoint of heat transfer and head resistance. Only the portion of the radiator really required for use need be outside of the fuselage where it will affect the resistance of the plane. Difficulties may be encountered, however, in the design of the fuselage for such an installation of the radiator

(3) Some attempts have been made to use a radiator pivoted about a vertical axis, so that it can be swung into or out from the air stream. This method is unsatisfactory because when the radiator is turned about, or yawed, on a vertical axis, the heat transfer is increased for certain angles while the head resistance is also greatly increased. This method not only fails to give satisfactory control of cooling capacity, but adds greatly to the absorption of power

(4) If the fuselage cannot be designed to accommodate a retractable radiator, the radiator can be divided into two parts and the two halves placed on opposite sides of the fuselage. This gives the advantage of an unobstructed position and allows control by shutters that may be two plates for each radiator, hinged at the side of the fuselage, to swing out and mask both the front and rear faces to any desired extent

(5) Shutters of the window-blind type are objectionable because they add greatly to the resistance of the radiator when closed, and their effect in increasing head resistance and decreasing air flow is by no means negligible when open

(6) Control by regulation of the water flow has been suggested, but no satisfactory method has been proposed. If the water is cut off from a part of the radiator, that part is likely to freeze at great altitudes or in cold weather; while a change in rate of flow is not practicable because, with rates commonly used in practice, the heat transfer is practically independent of the rate of flow

Altitude Effects on Performance

As an airplane rises to great altitudes, the decrease in density and temperature of the air have important effects upon the performance of the radiator. The reduction in temperature tends to increase the heat transfer in proportion to the increase in mean-temperature difference between the water in the radiator and the air through which it passes. The decrease in air density reduces the mass of air passing through the radiator for a given flying speed and thus tends to decrease the heat transfer by an amount corresponding, but not proportional, to the decrease in density.

Since the head resistance is practically proportional to the density of the air, the effect of the decrease in density is to reduce the head resistance for a given flying speed by an amount proportional to the decrease in density. The combined effect of density and temperature changes due to changes in altitude is to decrease the heat transfer for a given flying speed, but the head resistance is also decreased and for the higher speeds the figure of merit is in general somewhat increased. Estimates of probable densities and temperatures at altitude can be made from meteorological data, and the performance of a given radiator at altitude can be estimated from its performance at ground level by the use of the equations already given for air flow, heat transfer, head resistance, power absorbed and figure of merit.

Regarding the effects of engine and plane performance on radiator performance, the equation already given can also be used, with the aid of meteorological data, to estimate the performance of the radiator and the frontal area required, under varying conditions such as the maximum rate of climb or level flight at all altitudes, if enough is known about the performance of the engine and of the airplane to determine the flying speed, the rate at which heat must be dissipated and the lift/drag ratio of the airplane, under the different conditions.

CALIBRATION OF IMPROVED AIR SPEED INDICATOR

An air-speed indicator of the Robinson cup anemometer type with a centrifugal indicating mechanism has been calibrated by the Bureau of Standards. This instrument, which is of German manufacture, is small, very compact and well adapted for use on dirigibles. It is very nearly independent of changes in air density and gives the actual air speed. On the other hand, air-speed instruments of the pressure type are calibrated on the assumption that the density is uniform and give actual air speeds only for the standard air density value.—Air Service News Letter.

MAY COUNCIL MEETING

AT the meeting of the Council held on May 14 at President Vincent's office in Detroit the following were present in addition to President Vincent: First Vice-president, J. G. Utz, Second Vice-presidents W. G. Wall, H. C. Buffington and C. A. Criqui and Councilors F. M. Germane, E. A. DeWaters, E. A. Johnston and David Fergusson.

Farm Power Matters

A conference was held with President F. N. G. Kranich, of the American Society of Agricultural Engineers, with regard to cooperation with that society and the National Implement and Vehicle Association. Motorization in the farm power field has only just begun and every effort will be made to formulate, reduce to practice and present to all interested many much needed standards.

Treasurer's Report

The Treasurer's report showed that the Society income for the first five months of this fiscal year was just about what was contemplated in the annual budget, and the net expense for the period over $17,000 less than was allowed in the budget. On March 1 the total assets of the Society amounted to over $150,000. The average unexpended monthly income for October, November, December, January and February was $3,464.05; total, $17,320.25.

The final program for the Society meeting at Ottawa Beach June 21 to 25 was considered.

Membership

Fifty-six applications for membership were approved, sixteen for Member, two for Service, twenty-eight for Associate and fifteen for Junior grade. Norman Bell, W. O. Olsen, R. O. Sperry and R. S. Taylor were transferred from Associate to Member grade; W. S. Haggott, A. F. H. Scott and F. J. Sullivan from Junior to Member grade; and A. W. Moffat from Junior to Associate grade. Joseph J. Geisler was appointed instead of A. M. Fulton to represent the Fort Pitt Malleable Iron Co. under its affiliate membership.

The resignations of R. J. Firestone and A. W. Gaeblein were accepted.

Of the 242 applications for membership received since April 1, 60 per cent are to be credited to the effective work of the Membership Committee, of which W. A. Brush is chairman. The Council commended highly the work of the Committee. During April, 164 applications for membership were received, the professional standing of the new men being high. It is clear that the Society will continue to increase in size rapidly, as a surprising number of men who should be affiliated with it are still unattached. This is merely indicative of the continuing and increasing magnitude of the automotive industry. On May 1 there were 4798 on the rolls of the Society as compared with 4170 on the same day of 1919. The number of members delinquent in dues is being reduced to a decidedly low minimum. The organization of the staff and work of the Society is being strengthened greatly. The Society now has available for its use as offices the seventh floor of the Engineering Societies Building, New York, which has an area of approximately 7500 sq. ft.

Standardization

The following Standards Committee appointments were made at the May Council meeting, with assignment to Division as indicated:

R. M. Bird, Iron and Steel Division
Herbert C. Harrison, Radiator Division
N. E. Hildreth, Stationary Engine Division
E. B. Newill, Stationary Engine Division
C. I. Bradley, Tire and Rim Division
John Younger, Ball and Roller Bearings Division
H. J. Porter, Ball and Roller Bearings Division
A. H. Miller, Ball and Roller Bearings Division

One important action taken was to establish a Lubricants Division of the Standards Committee, work in this field having heretofore been within the jurisdiction of the Miscellaneous Division, and held in abeyance practically awaiting the result of tests being conducted here and abroad. Several of the oil producers, as well as automotive apparatus manufacturers, are undertaking systematic researches and it is trusted that the work in progress at the Bureau of Standards and the Bureau of Mines will yield valuable results.

The Committee on Petroleum Specifications of the Fuel Administration has recently published specifications after several months' study. These will serve in part as the basis of consideration of the S. A. E. committee. The makers of automotive apparatus were not consulted to any great extent, at least in the formation of the Government specifications mentioned. It is argued that existing specifications have been prepared more from the chemical laboratory standpoint than from the standpoint of the automotive engineer. The whole question is difficult and the new Society Lubricants Division will bring together the practical and technical information available and direct or suggest such additional experimental work as may seem necessary. The only specification for lubricating oil the Society has adopted is one for a paraffine-base light engine lubricating oil. The Society became the custodian of this standard many years ago, it having been established by the Association of Licensed Automobile Manufacturers, the predecessor of the National Automobile Chamber of Commerce.

The following additional subjects have been assigned to the Standards Committee for consideration:

Elastic cord for shock-absorbers—Aeronautic Division
Position of seat and controls—Aeronautic Division
Stay-wire lugs—Aeronautic Division
Fan hubs—Engine Division
Fuel tank mounting—Isolated Electric Lighting Plant Division
Serrated shaft fittings—Shaft Fittings Division
Tractor weight distribution—Tractor Division
Anti-freeze mixture—Tractor Division
Brake-drums—Tractor Division
Clamp-bolts for demountable pneumatic tires — Truck Division
Metal wheel felloes—Truck Division
Truck wheels—Truck Division

A communication received from the Bureau of Standards in connection with a proposed investigation of power losses in tires, to determine the accuracy of the specification requirements contained in War Department Catalog No. 10, was referred to the Tire and Rim Division of the Society.

It was reported that some of the principal makers of industrial trucks are not inclined to cooperate fully in the activities of the Industrial Truck and Tractor Subdivision of the Electric Transportation Division, but that a relatively large number of makers of these increasingly important apparatus are very desirous that a material amount of standardization shall be attempted in this field. It was the view of the Council that the procedure in this respect which has been inaugurated recently should be continued.

The Sections

The Council confirmed the payment this year from the treasury of the Society of $3,230 to the existing Sections of the Society located in eight different cities which are automotive centers. The respective payments are determined on a flat and Section numbership basis.

The action of the Indiana and the Metropolitan Sections in making amendment to their Constitution, By-Laws and Rules, to comply with the standard form, was approved.

The Council gave further consideration to the report to be made at the Ottawa Beach meeting by the Society committee on the utilization of present fuels in engines currently produced.

The Council referred to its Special Committee, of which H. E. Coffin is chairman, the matter of Society representation at a meeting in Washington June 3 and 4 called by the Joint Conference Committee of the Founder Engineering Societies, for the purpose of considering the establishment of an engineering "National Council."

The Council scheduled its next meeting for the afternoon of June 21 at Ottawa Beach, Mich.

THE GASOLINE SITUATION

As there appears to be some alarm in the country as to the gasoline situation, due, perhaps, to a misinterpretation of the facts. Acting Director F. G. Cottrell of the Bureau of Mines, Department of the Interior, has issued a statement as reflecting the opinion of the petroleum experts of the bureau. In this he says that while the gasoline situation appears to be in an acute stage in California, where there was only two weeks' supply in February, this is not now true in any other part of the country.

The production of gasoline in February, 1920, was about 11 per cent more than in the corresponding month in 1919, but the number of automobiles and trucks in use was about 25 per cent greater. It is anticipated that the production of gasoline will increase materially in the 1920 season through the increased installation of processes which will give a higher yield of gasoline from crude oil.

Stocks of gasoline in February of this year were approximately 563,000,000 gal., which is equivalent to fifty days' production. In the same month of 1919 gasoline stocks were 458,000,000 gal. or forty-five days' production. February stocks in 1918 were 524,000,000 gal., or sixty-two and one-half days' production. A survey of gasoline marketed in January of this year, as conducted by the Bureau of Mines, showed there had been no material change in the quality of gasoline over the year 1919.

It is stated by the *National Petroleum News* that the figures as to production in all fields for March indicate a healthy increase over January and February. The total production in March of this year, 36,491,000 bbl., shows a marked gain over March, 1919, when the total production was 30,234,000 bbl., and over March, 1918, when the figure was 29,664,000 bbl. The increase in production during March is particularly noticeable in the Appalachian district, where drilling is now most active in spite of the fact that the fields there were the first in the country. The production in Oklahoma and Kansas for March was 12,709,000 as against 11,500,000 bbl. in February. For most of the fields consumption for the month was under production and were it not for the heavy withdrawal in California, there would have been a slight addition to stocks for the whole country. Stocks all told as of March 31 were 125,291,000 bbl. On Dec. 31, 1919, they were 129,022,000 bbl. If production continues for the remaining three-quarters of 1920 at the same rate as for the first quarter, the total for 1920 will be over 410,000,000 bbl., an increase of approximately 11½ per cent over the total production for 1919, which was 377,719,000 bbl.

At a meeting held recently of representatives of the Society with members of the Committees of the American Petroleum Institute and of the National Automobile Chamber of Commerce, it was stated that the average production of gasoline from each gallon of crude was 22 per cent throughout the country, whereas at some refineries the percentage extracted has been for some time 35. It is obvious that if all or many of the refineries ran at the higher percentage there would be a greatly increased production of gasoline. As has been pointed out by Past-president Kettering, it would be possible today to increase very materially the fuel supply for automotive engines were it not for the fact that it is difficult to use satisfactorily the heavier fuels currently produced. In his view it is necessary to prevent the fuel from breaking down into objectionable compounds during combustion and to secure sufficiently normal combustion. It is estimated that there are now 6,500,000 passenger cars in use, with an expected production of 2,250,000 during this year. The corresponding figures for motor trucks are 700,000 and 500,000; for farm tractors 225,000 and 175,000; for motor boats 200,000 and 10,000, and for internal-combustion engines of the farm type 900,000 and 350,000.

Officers and Committee Personnel

THE personnel of the Council of the Society for the current year is given below. This is supplemented by lists of the members of the various Administrative Committees as appointed by President Vincent and the Standards Committee.

Officers and Members of the Council

J. G. Vincent, President
J. G. Utz, First Vice-president
W. G. Wall, Second Vice-president representing motor car engineering
G. L. Martin, Second Vice-president representing aviation engineering
H. C. Buffington, Second Vice-president representing tractor engineering
C. A. Criqui, Second Vice-president representing marine engineering
L. M. Ward, Second Vice-president representing stationary internal-combustion engineering

E. A. De Waters, Councilor
David Fergusson, Councilor
F. M. Germane, Councilor
E. A. Johnston, Councilor
Niran B. Pope, Councilor
A. W. Scarratt, Councilor
C. B. Whittelsey, Treasurer
C. M. Manly, Past President
Coker F. Clarkson, Secretary and General Manager

Administrative Committees

CONSTITUTION COMMITTEE

D. L. Gallup, *Chairman*

Edward Orton, Jr. W. G. Wall

FINANCE COMMITTEE

H. M. Swetland, *Chairman*

E. P. Chalfant G. H. Houston
Christian Girl Alfred Reeves

HOUSE COMMITTEE

Howard E. Coffin, *Chairman*

H. M. Crane J. M. Schoonmaker, Jr.
C. F. Kettering C. M. Vought

MEETINGS COMMITTEE

David Beecroft, *Chairman*

Azel Ames B. G. Koether
B. B. Ayers C. F. Scott

MEMBERSHIP COMMITTEE

W. A. Brush, *Chairman*

A. C. Bergmann Dent Parrett
H. A. Coffin John Younger

PUBLICATION COMMITTEE

Daniel Roesch, *Chairman*

Alexander Klemin H. C. Snow
H. C. Sadler G. A. Young

SECTIONS COMMITTEE

H. R. Corse, *Chairman*

J. A. Anglada C. B. Veal
J. E. Maloney A. D. Wilt, Jr.

Standards Committee

B. B. Bachman, *Chairman*

AERONAUTIC DIVISION

Henry M. Crane, *Chairman*

Commander A. K. Atkins C. B. Kirkham
Col. C. de F. Chandler G. C. Loening
Major V. E. Clark F. R. Porter
C. H. Day Commander H. C. Richardson
D. W. Douglas W. T. Thomas
W. L. Gilmore R. H. Upson
Major G. E. A. Hallett C. M. Vought
J. L. Harkness C. F. Willard
Commander J. C. Hunsaker
P. W. Wittemann

AUTOMOBILE LIGHTING DIVISION

Henry M. Crane, *Chairman*

Paul F. Bauder C. A. Michel
William T. Jones Edward S. Preston
W. A. McKay C. H. Sharp

BALL AND ROLLER BEARINGS DIVISION

W. R. Strickland, *Chairman*

W. C. Baker F. W. Gurney
W. L. Batt A. H. Miller
George R. Bott E. Nides
E. R. Carter, Jr. H. J. Porter
D. F. Chambers R. G. Schaffner
F. C. Goldsmith R. E. Wells
John Younger

Subdivision on Roller Bearings

W. C. Baker A. M. Laycock
T. V. Buckwalter R. G. Schaffner
L. R. Heim C. W. Spicer
R. E. Wells

ELECTRIC TRANSPORTATION DIVISION

E. R. Whitney, *Chairman*

Commercial Vehicle Subdivision

Edward L. Clark, *Chairman*

P. M. Holdsworth Frank E. Queeney
Charles A. Ward

Passenger Vehicle Subdivision

Karl Probst, *Chairman*

George M. Bacon

Battery Subdivision

Bruce Ford, *Chairman*

Walter H. Bancroft Walter E. Holland

Industrial Truck and Tractor Subdivision

J. M. Breitenbach, *Chairman*

Willard C. Brinton Albert H. Gfrorer
L. A. De More M. J. Harkless
Frank L. Eidmann E. H. Remde
Thomas T. Fauntleroy P. W. Saitta
H. W. Woodward

ELECTRICAL EQUIPMENT DIVISION

A. H. Timmerman, *Chairman*

F. W. Andrew W. A. Frederick
Joseph Bijur C. F. Gilchrist
R. J. Broege W. S. Haggott
Roger Chauveau Victor W. Kliesrath
W. A. Chryst T. L. Lee
Bruce Ford B. M. Leece
A. D. T. Libby

ENGINE DIVISION

H. C. Snow, *Chairman*

R. J. Broege E. G. Gunn
J. B. Fisher A. F. Milbrath
W. A. Frederick D. G. Roos
E. O. Spillman

IRON AND STEEL DIVISION

F. P. Gilligan, *Chairman*

J. S. Ayling C. N. Dawe
R. M. Bird E. L. French

Walter F. Graham
H. L. Greene
C. G. Heilman
E. T. Ickes
L. O. Koven
M. B. Morgan
John H. Nelson
G. L. Norris
J. H. Parker
W. C. Peterson
C. F. W. Rys
H. J. Stagg
R. A. Townsend
H. F. Wood

ISOLATED ELECTRIC LIGHTING PLANT DIVISION

L. S. Keilholtz, *Chairman*

T. P. Chase
G. M. Gardner
E. T. Gilliard
Lewis W. Heath
R. W. Randall
E. L. Russell
P. F. Shivers
George E. Tubbs
L. B. Williams

MARINE DIVISION

Joseph Van Blerck, *Chairman*

H. H. Brautigam
George F. Crouch
G. C. Davison
Kirk W. Dyer
H. E. Fromme
A. F. Milbrath
W. C. Morehead
Guy W. Vaughan

MISCELLANEOUS DIVISION

E. H. Ehrman, *Chairman*

F. C. Billings
Clarence Carson
W. C. Keys
W. R. Strickland
E. E. Sweet
Fred G. Whittington

MOTORCYCLE DIVISION

W. S. Harley, *Chairman*

George W. Dunham
C. B. Franklin
Major F. C. Hecox
F. W. Schwinn

NON-FERROUS METALS DIVISION

J. J. Aull, *Chairman*

E. Blough
G. K. Burgess
F. O. Clements
George K. Elliott
E. S. Fretz
H. L. Greene
Zay Jeffries
Charles Pack
H. P. Parrock
W. C. Peterson

RADIATOR DIVISION

Karl F. Walker, *Chairman*

J. D. Harris
Herbert C. Harrison
George W. Hoyt
W. S. James
A. Moorhouse
C. Oppe
C. T. Perkins
C. S. Sage
A. L. Swank
S. R. Swenson

ROLLER CHAIN DIVISION

L. M. Wainwright, *Chairman*

Warren J. Belcher
John R. Cautley
William F. Cole
Herbert F. Funke
H. S. Pierce

SHAFT FITTINGS DIVISION

C. W. Spicer, *Chairman*

J. F. Barr
R. J. Burrows
W. D. Diefendorf
R. R. Lapointe
W. C. Lipe
William MacGlashan
M. W. H. Wilson

SILENT CHAIN DIVISION

A. Ludlow Clayden, *Chairman*

Warren J. Belcher
John R. Cautley
Herbert F. Funke
John C. Howe
E. W. Mills
F. L. Morse
H. S. Pierce

SPRINGS DIVISION

W. M. Newkirk, *Chairman*

B. H. Blair
E. A. DeWaters
S. P. Hess
Harry R. McMahon
R. A. Schaaf
F. A. Whitten

STATIONARY ENGINE DIVISION

H. N. Edens, *Chairman*

L. F. Burger
N. E. Hildreth
Theodore C. Menges
E. B. Newill
L. M. Ward

TIRE AND RIM DIVISION

S. P. Thacher, *Chairman*

Pneumatic Tires for Passenger Cars Subdivision

S. P. Thacher, *Chairman*

W. H. Allen
E. G. Hulse
R. B. Naylor
J. C. Tuttle
W. S. Wolfe

Pneumatic Tires for Commercial Vehicles Subdivision

W. S. Wolfe, *Chairman*

W. H. Allen
L. R. Davis
E. G. Hulse
R. B. Naylor
J. C. Tuttle

Pneumatic Tires for Airplanes Subdivision

W. H. Allen, *Chairman*

R. B. Naylor
A. H. Petersen
S. M. Schott
J. C. Tuttle
W. S. Wolfe

Solid Tires Subdivision

A. Hargraves, *Chairman*

W. H. Allen
C. I. Bradley
L. R. Davis
Hugo Hoffstaedter
R. B. Naylor
A. H. Petersen

Pneumatic Tire Rims Subdivision

C. C. Carlton, *Chairman*

W. H. Allen
E. K. Baker
W. N. Booth
Lewis Fine
J. E. Hale
J. W. Holt
S. M. Schott
J. G. Swain
J. H. Wagenhorst

Solid Tire Bands and Rims Subdivision

W. N. Booth, *Chairman*

W. H. Allen
E. K. Baker
C. C. Carlton
L. R. Davis
Lewis Fine
J. E. Hale
A. Hargraves
J. W. Holt

TRACTOR DIVISION

E. A. Johnston, *Chairman*

H. C. Buffington
L. W. Chase
A. H. Gilbert
R. O. Hendrickson
Alfred Krieg
John Mainland
M. B. Morgan
Dent Parrett
C. B. Rose
A. W. Scarratt

TRANSMISSION DIVISION

A. W. Copland, *Chairman*

A. C. Bryan
L. C. Fuller
A. A. Gloetzner
W. C. Lipe
C. W. Spicer
W. G. Wall
E. E. Wemp
S. O. White

TRUCK DIVISION

L. P. Kalb, *Chairman*

F. G. Alborn
Ralph W. Austin
William M. Britton
A. K. Brumbaugh
E. L. Clark
J. R. Coleman
Francis W. Davis
Charles O. Guernsey
H. B. Knap
A. F. Masury
W. T. Norton, Jr.
A. J. Scaife
E. E. Wemp
F. A. Whitten
Capt. G. R. Young

Subdivision on Wheels

E. E. Wemp, *Chairman*

R. J. Burrows
F. L. Clark
Herbert S. Jandus
George L. Lavery
W. T. Norton, Jr.
J. G. Swain
Herbert Vanderbeek
A. S. Van Haltern

PERSONAL NOTES OF THE MEMBERS

W. P. Anderson, who was formerly manager of the Rich Steel Products Co., Battle Creek, Mich., is now associated with the production department of the Willys-Overland Co., Toledo, Ohio.

Joseph B. Armitage has resigned as mechanical engineer of the Aluminum Manufactures, Inc., Cleveland, and is now in charge of the engineering department of the Kearney & Trecker Co., Milwaukee.

Edward G. Batty is now chief mechanic and pilot with the Border Aerial Transportation Co., Windsor, Ont., Canada. He was formerly a draftsman in the employ of the McCord Mfg. Co., Detroit.

Joseph Berge has accepted a position as engineer of the research division of the General Motors Corporation, Dayton, Ohio.

W. P. Berrien is now vice-president and general manager of Cunningham & Berrien, Inc., 25 West Forty-third Street, New York City. He was formerly department manager of the Nemours Trading Corporation, also of New York City.

Archibald Black, who was aeronautical mechanical engineer in the aircraft division of the Bureau of Construction and Repair, Navy Department, Washington, is now one of the partners of A. & D. R. Black, Washington.

William C. Brooks has severed his connection with the Prest-O-Lite Co., Indianapolis, and has been appointed factory manager of the Hartford Battery Mfg. Co., Hartford, Conn.

Clarence C. Chronic has accepted a position as designing engineer with the Stover Mfg. & Engine Co., Freeport, Ill. He was formerly connected with the J. I. Case Threshing Machine Co, Racine, Wis.

Benjamin J. Cleaver, who was formerly connected with the General Motors Truck Co., Pontiac, Mich., is now experimental engineer with the Briscoe Devices Co., of the same city.

H. F. Comstock is now assistant service director of the Garford Motor Truck Co., Lima, Ohio.

Jefferson T. Conner, who was formerly specification engineer of the Continental Motors Corporation, Detroit, is now general manager of Charles H. Conner & Co., Louisville, Ky.

C. G. Cowan, who was formerly mechanical engineer with the Fisher Body Corporation, Detroit, is now staff engineer of L. V. Estes, Inc., Chicago.

W. P. Culver has severed his connection with the Perfection Spring Plant, Standard Parts Co., Cleveland, and is manager of sales for the American Autoparts Co., Detroit.

H. D. Dabney has been appointed executive secretary of the National Association of Motor Truck Sales Managers with offices after June 1, at Detroit.

William C. Davids has resigned his position as mechanical engineer with the W. & A. Fletcher Co., Hoboken, N. J., to accept the position of supervising engineer with William Gardner & Co., 1 Broadway, New York City.

Frank S. Davis has become associated with the Lexington Motor Co., Connersville, Ind. He was formerly chief engineer of the light and power engineering division, tractor works, International Harvester Co., Chicago.

A. Y. Dodge, who was formerly connected with the Wallis Tractor Co., Racine, Wis., has accepted the position of chief engineer with the Racine Engineering Co., of the same city. This is a firm of consulting engineers recently organized by Mr. Dodge and his associates.

Elmer D. Fox has accepted a position as assistant chief draftsman in the machine and tool division of the Hayes Wheel Co., Jackson, Mich. He was formerly in the production engineering department of the Bureau of Aircraft Production, McCook Field, Dayton. Ohio.

F. P. Gilligan, chairman of the Iron and Steel Division of the Standards Committee, has been appointed to represent the Society on the advisory committee for the joint investigation of the fatigue phenomena of metals that is being conducted by the Engineering Division of the National Research Council.

Louis J. Goldman has severed his connection with the Monroe Motor Co., Pontiac, Mich., and has organized the advertising firm of Louis J. Goldman, Inc., 1834 Broadway, New York City.

F. C. Haeske has accepted a position as production engineer with the Parish & Bingham Corporation, Cleveland. During the war he was a lieutenant in the Army.

J. C. Hooper, for five years in the sales engineering department of the Cincinnati Ball Crank Co., Cincinnati, has been appointed a member of the sales organization of the Oakes Co., Indianapolis.

Donald R. Husted has accepted a position as constructional engineer with the L. A. Thompson Scenic Railway Co., 220 West Forty-second Street, New York City. He was formerly aeronautical engineer of the Curtiss Aeroplane & Motor Corporation, Garden City, N. Y.

Courtney Johnson, formerly purchasing agent of the Dort Motor Car Co., Flint, Mich., is now assistant to the general manager of this company.

Ferdinand A. Keihn is now a designer with the International Motor Co., Sixty-fourth Street and West End Avenue, New York City. He was formerly connected with the L-W-F Engineering Corporation, College Point, N. Y.

Frank King has become affiliated with the Holcomb & Hoke Co., Indianapolis, as works manager. He was formerly chief mechanical engineer of the Columbia Graphophone Co., Bridgeport, Conn.

Thomas LaManna has accepted a position as aeronautical engineer at the Naval Aircraft Factory, Navy Yard, Philadelphia. He was formerly connected with the Longren Aircraft Corporation, Topeka, Kan.

Otto L. Lewis has resigned as chief engineer of the Southern Motor Mfg. Association, Houston, Tex. It is his intention to remain in that city and develop a line of power farming machinery which is particularly adapted to the needs of the Southern farmer.

Eric S. Locke has severed his connection with R. F. Chevalies, consulting engineer, and is now associated with the Heine-Velox Engineering Co., San Francisco.

Capt. William H. Mallon, formerly division motor transport officer of the First Division, A. E. F., is now assistant to the department motor transport officer in charge of the maintenance division, at the headquarters of the Southern Department, Fort Sam Houston, Tex.

Robert B. Mann has accepted a position with A. J. Slade, 1790 Broadway, New York City.

Clifford A. Miller has resigned as chief engineer of the Jones Gear Co., Cleveland.

Taliaferro Milton, assistant manager of the Chicago office of the Electric Storage Battery Co., has been appointed manager of that office.

C. E. Murray, who was formerly in the wholesale sales department of the Detroit office of the Willard Storage Battery Co., has been appointed district manager of wholesale sales at the Chicago office of the company.

Robert G. Nelson has been appointed assistant district manager of the San Francisco office of the Goodyear Tire & Rubber Co. He was formerly located at the Boston office of the same company.

H. H. Newsom has severed his connection with the Standard Parts Co., Cleveland, to become president of the Clay Engine Mfg. Co., also of that city.

S. V. Norton, representing the vice-president in charge of sales of the B. F. Goodrich Rubber Co., Akron, Ohio, has tendered his resignation to take effect June 1. He will in the future be associated with the General Motors Truck Co., Pontiac, Mich.

Benjamin S. Pfeiffer has resigned as sales engineer of the New Departure Mfg. Co., Bristol, Conn., with offices at Chi-

cago, to associate himself with the Page Co, consulting automotive and industrial engineers, also of the latter city. He is one of the pioneers of the tractor industry, having assisted in the design of one of the first self-lift plows which the Avery Co. placed on the market.

Douglas L. Phillips has severed his connection with Smith Brothers, Los Angeles, Cal., to accept the position of service manager with the Daniels Automobile Co. of Southern California, also located in that city.

E. C. Pohlmann has severed his connection with the *American Garage and Auto Dealer*, Chicago, to become president and general manager of the Pohlmann-Corcoran Co., also of that city.

J. P. Price has been appointed works manager of the Willys-Overland Co., Toledo, Ohio. He was formerly works manager of the Curtiss Aeroplane & Motor Corporation, Buffalo.

L. Robertson, who was formerly connected with the Service Motor Truck Co., Wabash, Ind., is now associated with the International Motor Co., New York City.

N. G. Rost, former sales manager for the Dusenberg Motors Corporation, has been elected vice-president in charge of sales and advertising for the Rochester Motors Corporation, Rochester, N. Y., with offices at 1778 Broadway, New York City.

L. L. Russell,, who was formerly chief of design section of the engineering division of the Motor Transport Corps, Washington, has accepted a position with the Rich Tool Co., Chicago.

H. S. Saltzman has accepted a position as chief engineer of the Southern Motor Mfg. Association, Houston, Tex.

M. Charles Schweinert is now president of A. Schrader's Sons, Inc., located at 783 Atlantic Avenue, Brooklyn, N. Y. He was formerly manager and treasurer of the same company, with headquarters in the New York office.

Howard L. Spohn has severed his connection with the Class Journal Co., New York City, to become vice-president of the Charles H. Fuller Co., Chicago.

Edwin S. Todd, treasurer and general manager of the Clark Brothers Bolt Co., Milldale, Conn., has been appointed receiver of the Rowe Calk & Chain Co., Plantsville, Conn., with full authority to continue the business of the latter company.

G. A. Ungar has been appointed general sales agent and consulting engineer of the Flexite division of Slocum, Avram & Slocum Laboratories, Inc., Newark, N. J., with offices in the Woolworth Building, New York City.

G. R. Wadsworth, formerly with the United Aircraft Engineering Corporation, 52 Vanderbilt Avenue, New York City, has opened an office at 501 Fifth Avenue, that city.

H. A. Warfel has resigned as chief draftsman of the Maxwell Motor Co., Newcastle, Ind., to accept a position as general manager of a newly organized firm to be known as the York Tool & Mfg. Co., located at Yorktown, Ind.

R. A. Watkins has accepted a position as works manager of the Clarinda Lawn Mower Co., Clarinda, Iowa.

Erwin A. Weiss has resigned as assistant manager of methods with the Isko Co., Chicago, to accept a position as service engineer with the Mitchell Motors Co., Racine, Wis.

Harry F. White has entered the employ of the General Motors Export Co., 1764 Broadway, New York City, in its technical department. He was formerly with the Federal Board of Vocational Education at Chicago.

C. S. Whitney has been appointed district manager of wholesale sales of the Detroit office of the Willard Storage Battery Co. He formerly filled the same position at the Chicago office of the company.

S. Wilson, formerly managing director of the Dublin Motor Co., Ltd., Dublin, Ireland, has become associated with the British Automotive Co., Ltd., London, England.

E. A. Winter is now chief engineer of the Jenkins Machine Co., Sheboygan, Wis. He was formerly factory manager of the Thompson Type Machine Co., Chicago.

Harold F. Wood has accepted a position with the Ingalls-Shepard Forging Co., Harvey, Ill. He was formerly metallurgical engineer of the Central Steel Co., Detroit.

OBITUARIES

ALBERT T. GENTNER, airplane engineer for the Curtiss Airplane & Motor Corporation, Buffalo, died on April 14, 1920, aged 28 years. He was born in that city April 24, 1892. His early education included a course in the Buffalo technical high school and was supplemented by private instruction in engineering. From 1909 to 1912 he was a machinist, engaged in tool making and pattern work for the Buffalo Machine Co., Buffalo, and from 1912 to 1915 a draftsman in the experimental engineering department of the Pierce-Arrow Motor Car Co., also of that city. He then became a designer and process engineer for the Curtiss interests and continued in their employ until his decease. He was elected to Associate Member grade in the Society, Jan. 23, 1919.

LOUIS J. MONAHAN, president and manager of the Universal Motor Co., Oshkosh, Wis., died at his home in that city Feb. 3, 1920. He was born at Oshkosh, Aug. 9, 1874. Following his common school education his technical knowledge was obtained through his own effort. For the past twenty years he had been a designer and manufacturer of gasoline engines of varied types and sizes. He organized the Termaat & Monahan Co. in 1902, which built stationary and marine engines. In 1914 he organized the Universal Motor Co., specializing on one size of four-cylinder engine and, in 1916, the Universal Foundry Co., for casting engine cylinders. His special interest in manufacturing was in marine engines and electric lighting plants. In 1908 he designed a grass-twine spinning machine which was adopted by two large industries and, in 1910, the first practical gasoline-engine locomotive, which was adopted by the Baldwin Locomotive Works. He was elected to Member grade in the Society of Automotive Engineers, June 21, 1917, and to full membership in the American Society of Mechanical Engineers in 1912.

FRANK A. WALTER, assistant chief engineer of the J. C. Degan Co., Inc., Chicago, died at his home in that city Jan. 19, 1920, aged 29 years. He was born at Chicago, July 30, 1890. Following his elementary education he became an inspector for the Woods Motor Vehicle Co., Chicago, in 1907, and advanced progressively to the position of designer. Later, he entered the employ of the Degan company and remained there until his death. His technical education was acquired mainly through his own unaided effort, supplemented by the evening courses of the Armour Institute. He was elected to Junior Member grade in the Society, Oct. 19, 1912.

ACTIVITIES OF THE SECTIONS

OFFICERS for the year 1920-21 have been elected by all of the Sections and have entered upon the duties pertaining to the respective positions. A complete list of the newly chosen officers is as follows:

BUFFALO SECTION

Chairman .....C. F. Magoffin
Vice-chairman .....E. T. Mathewson
Secretary .....R. Chauveau
Treasurer .....J. C. Talcott

CLEVELAND SECTION

Chairman .....H. G. Welfare
Vice-chairman .....H. C. Snow
Secretary .....A. E. Jackman
Treasurer .....K. B. Britton

DETROIT SECTION

Chairman .....E. G. Gunn
Vice-chairman .....Howard A. Coffin
Secretary .....M. Howard Cox
Treasurer .....E. W. Seaholm

INDIANA SECTION

Chairman .....Chester Ricker
Vice-chairman .....D. L. Gallup
Secretary .....E. B. Reeser
Treasurer .....J. E. Padgett

METROPOLITAN SECTION

Chairman .....A. M. Wolf
Vice-chairman .....A. C. Bergmann
Secretary .....M. C. Horine
Treasurer .....L. G. Nilson

MID-WEST SECTION

Chairman .....George T. Briggs
Vice-chairman .....Dent Parrett
Secretary ..... L. S. Sheldrick
Treasurer .....Walter S. Nathan

MINNEAPOLIS SECTION

Chairman .....A. W. Scarratt
Vice-chairman .....R. S. Kinkead
Secretary .....C. T. Stevens
Treasurer .....J. S. Clapper

PENNSYLVANIA SECTION

Chairman .....G. W. Smith, Jr.
Vice-chairman .....A. K. Brumbaugh
Secretary .....H. Hollerith, Jr.
Treasurer .....J. T. O'Neill

The elections of representatives of the Sections on the Society Nominating Committee have resulted in the naming of the following, with alternates as indicated:

Section	*Delegate*	*Alternate*
Buffalo	R. Chauveau	F. W. Davis and H. R. Corse
Cleveland	E. Wooler	F. W. Slack
Detroit	W. A. Brush	W. B. Stout
Indiana	Lon R. Smith	D. L. Gallup
Metropolitan	Norman Bell	N. B. Pope
Minneapolis	A. W. Scarratt	C. T. Stevens
Pennsylvania	A. K. Brumbaugh	B. B. Bachman

The Pennsylvania Section has held most of its meetings at the Philadelphia Engineers' Club, but having decided that as a concluding feature of its year's program there could be no more acceptable speaker than Past-president Kettering, engaged Witherspoon Hall for the large audience that was naturally expected. The meeting was held on the evening of April 22. The members who heard Mr. Kettering received more than the value of their Section dues right then and there. Future Engineering Possibilities as Indicated by the Progress of Modern Science was the handicap under which he started. He was not long in overcoming this, however, and his talk on fuels contained many American thermal units.

The spring outing of the Pennsylvania Section was held on May 22 at Strath Haven Inn, Swarthmore, Pa. This was the last meeting of the season and like all Pennsylvania Section affairs was a decided success.

The Indiana Section also had Mr. Kettering as the speaker at the final meeting of the season. Nearly 600 members and guests were present at the meeting on April 30 and only the inability of the Claypool Hotel to accommodate a larger number prevented a greater attendance.

W. V. Logan of the United States Tire Co., who is a strong advocate of the use of pneumatic tires for light trucks, talked before the Metropolitan Section at the Automobile Club of America, New York City, on the evening of May 12 and enumerated the points of superiority which he declared pneumatic tires have over either solid or cushion tires. These items consisted of greater possible speed and therefore a wider radius of action, smaller maintenance cost due to the greater cushioning effect, decreased consumption of gasoline and oil, less wear on the highways and a reduction in the breakage of cargo.

In the discussion which followed a number of other points were made by Messrs. Manly, Horine and Favary and by Col. A. J. Slade. It was suggested that if in the future pneumatic tires were to supplant solid tires on new equipment it might be possible to design the truck so that considerable weight would be saved. The possibility of punctures was touched upon but the experience of the members seemed to show that little is to be feared from this.

It was brought out, however, that the speed of the truck depends upon its engine speed, gear ratio and wheel diameter, and that any increase in speed could be attained only at a sacrifice in hill-climbing ability unless the speed of the engine were increased; and that it is inadvisable to run the truck engine at too high speed. Another point in objection to the use of pneumatic tires was that with the present highways a pneumatic tire when running at high speed is apt, due to its suction, to damage the roads more than would be the case by the pounding of a solid tire.

In connection with legislation in process of enactment restricting and controlling the use of trucks on highways, it was brought out that it is important to know what tire construction is least harmful to the road.

Mr. Logan's talk was followed by moving pictures showing the process of tire manufacture and by Novograph pictures of the action of trucks equipped with both pneumatic and solid tires in going over curbstones and other obstructions.

The interest in the fuel situation is so great that the subject is constantly recurring in one form or another. John C. Willett of the Sterling Oil Corporation read before the Buffalo Section on April 28 a paper in which he considered the controlling and atomizing of the fuel by the variable pressure of the engine. He spoke of the improvements which have been made in the carbureters but called attention to the fact that none of them has entirely solved the problem.

Those who attended the meeting of the Cleveland Section in March and heard J. H. Hunt's paper on the advantages of battery ignition were out in full force at the next meeting of the Section on April 16 when A. D. T. Libby of the Splitdorf Electrical Co. spoke of the advantages of the magneto for ignition purposes. Both the paper by Mr. Hunt and the one by Mr. Libby will appear in an early issue of THE JOURNAL.

The final technical meeting of the Cleveland Section was held at the Elks Club, Cleveland, May 21. After dinner a paper was read on Automobile Tire Construction, Past, Present and Future and a moving picture comedy entitled A Tire Strike was shown. The Section will conclude its very successful year with an outing during the summer months.

Arrangements have been made for a special Pullman for the members of the Cleveland Section attending the Summer Meeting. This car will leave Cleveland late Sunday evening, June 20, and enable the members to reach Ottawa Beach in time for the opening of the meeting on Monday morning.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between April 17 and May 14, 1920. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (E S) Enrolled Student; (S M) Service Member; (F M) Foreign Member.

AMERICAN MANGANESE BRONZE CO. (Aff) Holmesburg, *Philadelphia.* Representatives: T. H. Addie, vice-president and treasurer; C. R. Spare, vice-president and manager.

APOR, EMIL LAWRENCE (E S) student, Purdue University, *West Lafayette, Ind.,* (mail) 223 Pierce Street.

BAASCH, CHARLES (M) designer of automobile bodies, 1823 Broadway, *New York City.*

BAILEY, ETHEL H. (MISS) (J) assistant to head of the specification department, Bureau of Construction and Repair, Navy Department, *Washington,* (mail) 25 Rock Creek Church Road, Northwest.

BANTA, C. E. (M) manager, automobile accessories department, Adams & Westlake Co., 319 West Ontario Street, *Chicago.*

BIXBY, GEORGE LINDER (M) research engineer and service manager, Detroit Electric Car Co., *Detroit,* (mail) 109 Webb Avenue.

BOCKMANN, ARTHUR C. (A) service manager, Union Automobile Co., Inc., Union Hill, N. J., (mail) 729 Bergenline Avenue, *West New York, N. J.*

BURNHAM, CHARLES H. (E S) student, Massachusetts Institute of Technology, Cambridge, Mass., (mail) 68 Brookside Avenue, *Newtonville, Mass.*

CASLER, HERMAN (M) vice-president and consulting engineer, Watson Products Corporation, *Canastota, N. Y.*

CHARLES, RICHARD E. (J) stock supervisor, Buick Motor Co., *New York City,* (mail) 139 Alexander Avenue.

CHILDERS, FOUST (J) assistant supervisor, assembly department Remy Electric Division, General Motors Corporation, *Anderson, Ind.,* (mail) 2220 Jackson Street.

CLUCAS, W. J. (A) sales representative, Lancaster Steel Products Corporation, Lancaster, Pa., (mail) Lancaster Steel Products, Cass and Milwaukee Avenues, *Detroit.*

CRAWFORD, JOHN X. (J) automobile mechanic, Clark & Kendrick, Inc., 126 West Fiftieth Street, *New York City.*

CUMMING, WILLIAM J. (M) designer of pneumatic tires for motor trucks, Goodyear Tire & Rubber Co., *Akron, Ohio,* (mail) 868 Avon Street.

DICK, WILLIAM F. (J) draftsman, Walden W. Shaw Livery Co., *Chicago,* (mail) 1429 South Keeler Avenue.

DOOLITTLE, ALBERT HALL (A) general manager, Claudel Carburetor Co., 192 Jackson Avenue, *Long Island City, N. Y.*

EDWARDS, CLARENCE E. (M) chief draftsman, Bethlehem Motors Corporation, East Allentown, Pa., (mail) 627 North Sixteenth Street, *Allentown, Pa.*

ELDRIDGE, J. G. (A) draftsman, Duplex Truck Co., *Lansing, Mich.,* (mail) 323 South Walnut Street.

FAIRBANK, L. G. (A) vice-president and manager, Firestone Steel Products Co., *Akron, Ohio.*

FASNACHT, H. H. (A) chief engineer, Shafer Bearing Corporation, *Chicago,* (mail) Ravenswood and Sunnyside Avenues.

GEIGER, JOHN W. (E S) student, Purdue University, *West Lafayette, Ind.,* (mail) 328 Lutz Avenue.

GELLATLY, WILLIAM R. (A) purchasing agent, Pittsburgh Model Engine Co., Frick Building, *Pittsburgh.*

GOODRICH, R. H. (M) chief draftsman, L-M Axle Co., *Cleveland,* (mail) Doanbrooke Hotel, 1924 East 105th Street.

GOREY, JOSEPH C. (A) president, Joseph C. Gorey & Co., 354 West Fiftieth Street, *New York City.*

GORING, RICHARD G. (M) engineering representative, Fellows Gear Shaper Co., *Springfield, Vt.*

GREGG, DAVID (M) military aviator, 5 Bartlett Crescent, *Brookline, Mass.*

HACKETT, CLYDE O. (J) draftsman, National Motor Car & Vehicle Corporation, *Indianapolis,* (mail) 216 East Nineteenth Street.

HALL, PAUL BISHOP (J) assistant general manager, American Die-Casting Co., 212 West McCarty Street, *Indianapolis.*

HASKINS, L. O. (A) vice-president and sales manager, Powrlok Co., 1107 East 152nd Street, *Cleveland.*

HILL, L. CLAYTON (M) assistant general manager, Society of Automotive Engineers, Inc., New York City, (mail) Rock Lane, Douglas Manor, *Douglaston, N. Y.*

HUESENER, H. B. (A) consulting engineer, Universal Products Co., Sandusky, Ohio, (mail) Universal Products Co., 6 Hay Building, *Oshkosh, Wis.*

IMURA, JUN-ICHI (M) director, Tokyo Automotive College, Tokyo, Japan, (mail) 607 West 139th Street, *New York City.*

KAVANAUGH, CHARLES C. (A) service manager, Jennings-Burkett Motor Co., *Sumter, S. C.,* (mail) Box 129.

KLINGHOLZ, C. O. (A) factory manager, Shaw Association, Ltd., Tractor Department, *Boyne City, Mich.*

LASLEY, DANA MCGUFFEY (M) sales engineer, motor division, Wellman-Seaver-Morgan Co., Akron, Ohio, (mail) 183 Fischer Avenue, *Detroit.*

LIEBREICH, OSCAR P. (J) student, Rensselear Polytechnic Institute, *Troy, N. Y.,* (mail) 10 First Street.

LUHRING, MARIE (MISS) (A) draftsman, International Motor Co., *New York City,* (mail) 661 West 178th Street.

MARTIN, FRANK H. (A) manager, Stewart-Warner Speedometer Corporation, Chicago, (mail) 1551 Woodward Avenue, *Detroit.*

MAYER, KARL HERMAN (M) assistant chief engineer, Torbensen Axle Co., Cleveland, (mail) 803 Lenox Hotel, *Detroit.*

MICHELAT, LÉON (M) chief engineer, Delage & Cie, á Courbevoie, Seine, *France,* (mail) 19 rue de Bretagne, *á Asnieres.*

MOSES, ADOLPH (M) engine designer, Curtiss Engineering Corporation, Garden City, N. Y., (mail) 99 William Street, *Hempstead, N. Y.*

MOUGEY, HARRY CLIFFORD (M) control chemist, Dayton Wright Division, General Motors Corporation, 219 Indiana Avenue, *Dayton, Ohio.*

NATIONAL IMPLEMENT AND VEHICLE ASSOCIATION (Aff) *Chicago.* Representative: H. J. Sameit, acting secretary.

NEUMANN, ALAN B. (J) assistant development engineer, International Harvester Co., *Chicago,* (mail) 825 East Forty-ninth Street.

NICYPER, HENRY R. (J) engineer, Wabash Tractor Co., *Wabash, Ind.*

NORRIS, ALFRED G. (A) district manager, S K F Industries, Inc., New York City, (mail) 622 Chamber of Commerce Building, *New Haven, Conn.*

OHMER, ROBERT F. (A) sales manager, Recording & Computing Machines Co., *Dayton, Ohio.*

OLBETER, M. (M) chief engineer, Keystone Motor Truck Co., *Philadelphia,* (mail) 1510 West Tioga Street.

OLIVER, GEORGE R. (J) designer, General Motors Truck Co., *Pontiac, Mich.,* (mail) 151 North Johnson Avenue.

O'NEILL, J. T. (A) assistant sales manager, Standard Steel & Bearings, Inc., *Philadelphia,* (mail) 5001 Lancaster Avenue.

OWERSTROM, ROBERT A. (J) machine draftsman, Amalgamated Machinery Corporation, *Chicago,* (mail) 915 Newport Avenue.

PERRY, EDWARD DEWOLF (M) chief tool engineer, Watson Products Corporation, *Canastota, N. Y.,* (mail) Box 626.

PETERS, O. M. (M) general manager, Clark Brothers Co., Olean, N. Y., (mail) 935 North Church Street, *Rockford, Ill.*

PFEIFFER, RUDOLF SALISBURY (J) chief tester, experimental department, Holt Mfg. Co., *Peoria, Ill.,* (mail) 1108 North Madison Avenue.

ROLLS-ROYCE OF AMERICA, INC. (Aff) *Springfield, Mass.* Representatives: H. C. Beaver, treasurer; L. J. Belnap, president; E. A. Claremont, vice-president; John J. McManus, secretary.

ROSNER, ADOLPH (M) engineer in charge of testing, American Bosch Magneto Corporation, Springfield, Mass. (mail) 1166 Kossuth Street, *Bridgeport, Conn.*

ROZIAN, H. W. (M) body designer, Federal Motor Truck Co., *Detroit,* (mail) 732 Campbell Avenue.

SCHOTT, SIDNEY M. (M) secretary, development department, Morgan & Wright Plant, United States Rubber Co., *Detroit.*

SMITH, EARL H. (J) trouble analysis engineer, Nordyke & Marmon Co., *Indianapolis, Ind.,* (mail) 940 Middle Drive, Woodruff Place.

SNEAD, IRA SCOTT (M) general sales manager, Snead & Co. Iron Works, foot of Pine Street, *Jersey City, N. J.*

SOUTHARD, GEORGE H., JR. (M) treasurer, general manager, J & B Mfg. Co., 65 Eagle Street, *Pittsfield, Mass.*

SPOONER, ROBERT HENRY (M) experimental engineer, Winton Co., 10601 Berea Road, *Cleveland.*

STANLEY, F. C. (M) chemist, Raybestos Co., *Bridgeport, Conn.*

STONE, SELDEN EARL (J) manager, electrical department, Durham Battery Service Station, *Durham, N. C.*

THOMAS, CHARLES BRUNER (E S) student, Purdue University, Lafayette, Ind., (mail) 210 Seminary Street, *Greencastle, Ind.*

TRIPP, L. L. (A) president, Albany Boat Corporation, *Watervliet, N. Y.*

TUCKER, JOHN O. (A) district sales manager, La Belle Iron Works, Steubenville, Ohio (mail) 1221 Book Building, *Detroit.*

OCHTMAN, ARTHUR F. (J) service man, Van Blerck Motor Co., *Monroe, Mich.,* (mail) 51 South Macomb Street.

WANTANABE, SABRO (F M) managing director, Japan Special Steel Co., Omori, Tokyo, Japan, (mail) 10 Mishima-cho, *Shibaku, Tokyo.*

WARREN, R. M. (M) member of firm, Warren Brothers Garage, *Sumter, S. C.,* (mail) Box 126.

WHITE, RALPH (M) designing engineer, Edward G. Budd Mfg. Co., *Philadelphia,* (mail) 5053 Brown Street.

WIKANDER, OSCAR R. (M) consulting engineer, S K F Industries, Inc., 165 Broadway, *New York City.*

WILLGOOS, ANDREW V. D. (M) chief draftsman, Wright Aeronautical Corporation, *New Brunswick, N. J.,* (mail) 1 Rutgers Street.

WILLIAMS, H. R. (A) general manager, Beaver Truck Builders, Ltd., *Hamilton, Ont., Canada.*

WILLIAMS, HARRY (J) designer, Chevrolet Automobile Co., New York City, (mail) 37 Waverly Street, *Jersey City, N. J.*

WILLIAMS, LAWRENCE S. (J) chief draftsman, Borg & Beck Co., 6558 South Menard Avenue, *Chicago.*

WINKLER, FRED C. (J) draftsman, Bendix Engine Works, *South Bend, Ind.*, (mail) 937 South Bend Avenue.

WOODROW, MAURICE R. (J) factory representative, Stokes Carbureter Co., Inc., New York City, (mail) 3110 Emerson Avenue, South, *Minneapolis.*

YONEMOTO, SHINJI (E S) University of Michigan, *Ann Arbor, Mich.*, (mail) 1209 East University Avenue.

YOUNG, HUGO H. (M) vice-president, treasurer and general manager, Flexible Co., *Loudonville, Ohio.*

ZIMMERMAN, THOMAS (M) chief engineer, Standard Parts Co., Cleveland, (mail) 3205 Euclid Heights Boulevard, *Cleveland Heights.*

Applicants *for* Membership

The applications for membership received between April 24 and May 24, 1920, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ACKERMANS, JOHN W. J., experimental and sample body engineer, E. J. Thompson Co., *Pittsburgh.*

ADLER, WILLIAM KARL, assistant electrical engineer, International Harvester Co., *Chicago.*

AKE, MERLIN E., superintendent of production, Firestone Tire & Rubber Co., *Akron, Ohio.*

ALLAN, ROY C., engineer, Stromberg Motor Devices Co., *Chicago.*

ALLISON, PHILIP W., mechanical engineer, Smith, Hinchman & Grylls, Washington Arcade, *Detroit.*

ASHLEY, ERNEST GILMAN, manager, Hall & Pickles, Ltd., *Manchester, England.*

AUSTIN, W. S., chief engineer, Symington, Hoffman & Co., *Baltimore.*

BAKER, BRYON G., general manager, Canadian Tillsoil Farm Motors Co., *Winnipeg, Canada.*

BAKER, L. L., chief draftsman, King Motor Car Co., *Detroit.*

BASSETT, A. F., sales engineer, Hyatt Roller Bearing Co., *Detroit.*

BAXTER, KENNETH S., vice-president and general manager, Sheet Steel Products Co., *Michigan City, Ind.*

BAYSTON, JOHN R., engineer, American Technical Society, *Chicago.*

BEECK, JOSEPH, aeronautical mechanical engineer, Air Service, *Washington.*

BIHL, WILLIAM E., layout draftsman, Iron Mountain Co., *Chicago.*

BISSELL, P. R., automobile designer, Reo Motor Car Co., *Lansing, Mich.*

BLAINE, EARL C., layout draftsman, Buick Motor Co., *Flint, Mich.*

BLAKE, H. FRASER, sales engineer, Doehler Die-Casting Co., *Brooklyn, N. Y.*

BLOMSTROM, HARRY LEONARD, production manager, Pittsburgh Model Engine Co., *Pittsburgh.*

BOWMAN, CHRISTIAN C., experimental engineering, Standard Motor Truck Co., *Detroit.*

BRAMHALL, MAYNARD, sales engineer, Hyatt Roller Bearing Co., *Detroit.*

BRAND, PAUL H., chief engineer, Little Giant Co., *Mankato, Minn.*

BRAUNSCHWEIGER, P. G., superintendent, Troy Body Co., *Troy, Ohio.*

BRODT, BURTON WELLS, sales engineer, American Auto Parts Co., *Detroit.*

BROWN, FRANK L., second vice-president, Columbia Steel & Shafting Co., *Pittsburgh.*

BROWN, GEORGE M., engineer, Liberty Devices Co., *Boston.*

BUETTNER, WALTER J., secretary, Bendix Engineering Works, *South Bend, Ind.*

CARLTON, CHESTER L., draftsman, Chandler Motor Car Co., *Cleveland.*

CHAFFE, J. B., JR., mechanical engineer, Aluminum Manufactures, Inc., *Cleveland.*

CHANDLER, R. W., director industrial research, Yale & Towne Mfg. Co., *Stamford, Conn.*

CHAUDET, W. J., tool and production engineer, Traffic Motor Truck Corporation, *St. Louis.*

CHOATE, F. P., department manager, Sears, Roebuck Co., *Chicago.*

CLOYD, P. C., sales engineer, Willard Storage Battery Co., *Chicago.*

COOK, RICHARD C., sales agency, R. C. Cook Co., 2929 Wabash Avenue, *Chicago.*

COOKE, DWIGHT IRVING, sales engineer, Hercules Motor Mfg. Co., *Canton, Ohio.*

COOPER, WILLIAM M., chief engineer, General Aluminum & Brass Mfg. Co., *Detroit.*

CURRIE, ARCHIBALD P., chief draftsman, Dominion Steel Products Co., Ltd., *Brantford, Ont., Canada.*

CURTISS, CHARLES B., engineer of sales, Bay City Foundry & Machine Co., *Bay City, Mich.*

DARROW, H. W., factory representative, Firestone Tire & Rubber Co., *Akron, Ohio.*

DEIDRICK, H. W., instructor of automobile mechanics, Camp Zachary Taylor, *Louisville, Ky.*

DELP, M. Z., assistant spring engineer, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*

DEVRIES, E. E., superintendent, Traffic Motor Truck Corporation, *St. Louis.*

DOLLIN, EDGAR N., general manager, Precision Castings Co., Inc., *Syracuse, N. Y.*

DOUNE, E. C., mechanic, International Motor Co., *Plainfield, N. J.*

DUKE, A. MCNEE, automotive draftsman, Standard Engineering Co., *St. Louis.*

DUNCAN, CHARLES R., layout draftsman, F. H. Berger, *Detroit.*

DUNHAM, CLIFFORD ANDERSON, district manager, B. F. Goodrich Rubber Co., *Akron, Ohio.*

DUNSTER, RAYMOND WILSON, chief draftsman, Vulcan Mfg. Co., *Seattle, Wash.*

DUSEVOIR, JULIUS, automotive engineer, Chevrolet Agency, *Hollywood, Cal.*

ECKERSON, R. M., service engineer, Continental Motors Corporation, *Detroit.*

ELCONIN, E. V., chief engineer, Eaton Axle Co., *Cleveland.*

FANNING, FRANK J., president, Fanning Hatch Co., *Philadelphia.*

FARR, ARTHUR V., sales manager, Hess Steel Corporation, *Baltimore.*

FOWLER, RUSSELL W., draftsman, Rutenber Motor Co., *Marion, Ind.*

FRAZEE, W. B., general sales manager, Southern Automobile Mfg. Co., Inc., *Memphis, Tenn.*

FREDERICKS, ELMER VICTOR, sales manager, Arc-O-Mfg. Co., *Chicago.*

FRITCH, GILES MORTON, technical supervisor, American Brass Co., *Kenosha, Wis.*

FURUBAYASHI, USABURO, chief inspector, Tokyo Gas & Electric Engineering Co., Ltd., Omori, *Tokyo, Japan.*

GOODWIN, HAROLD F., salesman, Aluminum Manufactures, Inc., *Cleveland.*

GROVE, N. E., truck sales, International Motor Co., *New York City.*

GUYOT, MARIUS G., mold designer, Aluminum Manufactures, Inc., Harvard Avenue, *Cleveland.*

HANSON, MILES G., superintendent, Willys Corporation, *Toledo, Ohio.*

HAVEN, KENT CONVERSE, experimental engineer, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

HOLLAND, KIRK DAVIS, general manager, Double Seal Ring Co., *Chicago.*

HOLMES, BRADFORD B., chief engineer, Miller Reese Hutchison, Inc., Woolworth Building, *New York City.*

HOLSTEAD, JOHN WILLIAM, mechanical engineer, E. W. Bliss Co., *Brooklyn, N. Y.*

HOLZAEPFEL, NORMAN R., draftsman, Otis Steel Co., *Cleveland.*

HOWARD, WILLIAM D. M., consulting mechanical engineer, 45 Islington Road, *Auburndale 66, Mass.*

HOWE, EARL E., mechanical engineer, Universal Rim Co. and Baker Wheel & Rim Co., *Chicago.*

IRONSIDE, FREDERICK MARTIN, mechanical engineer, E. W. Bliss Co., *Brooklyn, N. Y.*

JACKLIN, H. M., assistant chief engineer, Oneida Motor Truck Co., *Green Bay, Wis.*

JACKSON, FRANK R., sales engineer, Claudel Carburetor Co., *Long Island City, N. Y.*

JEFFERS, R. L., draftsman, Supreme Motors Corporation, *Warren, Ohio.*

JEFFRIES, SCHUYLER A., designer, Reo Motor Car Co., *Lansing, Mich.*

JOHNSON, HUGH A., assistant engineer, Hupp Motor Car Corporation, *Detroit.*

JOHNSTON, HOWARD A., manager sales, Standard Steel & Bearings, Inc., *Philadelphia.*

JONES, MAJOR BYRON QUINBY, Air Service, *Washington.*

JONES, EDWIN OLNEY, sales engineer, Federal Bearing & Bushing Corporation, *Detroit.*

JUDD, MORTON F., sales manager, Raybestos Co., *Bridgeport, Conn.*

JURS, ALBERT E., manager of production, Fageol Motors Co. of Ohio, *Oakland, Cal.*

KEAGY, A. REUEL, sales engineering, Republic Motor Truck Co., Inc., *Alma, Mich.*

KEEFE, JOSEPH, estimator, Nelson Blower & Furnace Co., *South Boston.*

KING, COSBY, draftsman, Superior Motor Truck Co., *Atlanta, Ga.*

KINNEY, JOHN M., supervisor of motor cars, Southern Pacific Railway, *Sacramento, Cal.*

KIRMAN, RICHARD, JR., mechanic, Mack Brothers, Inc., *Reno, Nev.*

KLEIN, FREDERICK H., draftsman, Nelson Blower & Furnace Co., *South Boston.*

LANGHAMMER, A. J., industrial engineer, Thompson & Black, 99 Marston Avenue, *Detroit.*

LARSON, LOUIS V., sales engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

LAY, ROBERT P., special engineer, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

LEACH, HARRY G., engineer, Electrical Industries Mfg. Co., *New York City.*

LINDH, FRITZ P., Holt Mfg. Co., *Peoria, Ill.*

LINSLEY, DOUGLAS F., engineer, C. Harold Wills, *Detroit.*

LOGAN, JOSEPH S., production schedule, Warner Gear Co., *Muncie, Ind.*

LOHR, CHARLES E., production manager, Chandler Motor Car Co., *Cleveland.*

LUNDBERG, VICTOR A., *Waubay, S. D.*

MCCALEB, S. N., manager transportation department, Nash-Denver Motor Co., *Denver.*

MCDONALD, A. J., manager of sales, Lebanon Steel Foundry, *Lebanon, Pa.*

MCINTYRE, JOHN W., student, Tri-State College of Enginering, *Angola, Ind.*

MCLEOD, ALEXANDER, staff engineer, Sinclair Refining Co., *Chicago.*

MACVEIGH, J. H., sales manager, Pressed Steel Co., *Wilkes-Barre, Pa.*

MAMMEN, H. P., treasurer, Traffic Motor Truck Corporation, *St. Louis.*

MANVILLE, TRACY F., general manager of sales, Columbia Steel & Shafting Co., *Pittsburgh.*

MARTIN, ADALBERT L., technical service, Splitdorf Service & Sales Co., *Chicago.*

MARTIN, CHARLES C., engineer, automotive department, Kilbourne & Jacobs Mfg. Co., *Columbus, Ohio.*

MAURER, VERNON H., engineer, sales, Stewart-Warner Speedometer Corporation, *Chicago.*

MEERBECK, AUGUST F., superintendent, Osgood Bradley Car Co., *Worcester, Mass.*

MEISTER, FIRST-LIEUT. LOUIS G., engineering division, Air Service, McCook Field, *Dayton, Ohio.*

MILES, CHARLES, experimental engineer, International Harvester Co., *Akron, Ohio.*

MOODY, COL. LUCIAN B., Ordnance Department, *Washington.*

MOORE, A. W., district manager, Firestone Tire & Rubber Co., *Akron, Ohio.*

MOORE, FEARON D., technical representative, General Motors Export Co., *New York City.*

NELSON, EDGAR H., service draftsman, United States Ball Bearing Mfg. Co., *Chicago.*

NEWILL, E. B., engineer, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

NICHOLSON, JOSEPH P., layout draftsman, Scripps-Booth Corporation, *Detroit.*

NORRIS, ALFRED E., sales engineer, Simms Magneto Co., *East Orange, N. J.*

OLIVIER, H. C., mechanical engineer, van Lennepweg 10, *den Haag, Holland.*

OLSON, CLARENCE T., draftsman, United States Ball Bearing Mfg Co., *Chicago.*

ONG, HUBERT, instructor, Army Automotive Department, Camp Zachary Taylor, *Louisville, Ky.*

OWEN, WILLIAM, chief tool designer, Pittsburgh Model Engine Co., *Pittsburgh.*

PALMER, RALPH B., chief engineer, J. W. Murray Mfg. Co., *Detroit.*

PARKER, HARRY, designer, Superior Motor Truck Co., *Atlanta.*

PAUL, WALTER E., foreman, Nordyke & Marmon Co., *Indianapolis, Ind.*

PEEL, WILLIAM E., works manager, British Ensign Motors Ltd., *London, N. W., 10, England.*

PHILLIPS, ANDREW E., designer, Standard Parts Co., *Cleveland.*

PORTER, R. E., manager of equipment department, Gibson Co., *Indianapolis.*

PURVIS, JOHN W., designing engineer, McCord Mfg. Co., *Detroit.*

RODWAY, G. H., chief engineer, Wolseley Motors, Adderley Park, *Birmingham, England.*

ROUALET, ANDREW J. E., automotive expert, L. C. Buxton, *Los Angeles, Cal.*

ROUDENBUSH, ELMER F., truck designer and checker, Stewart Motor Corporation, *Buffalo.*

ROWLES, WILLIAM C., production manager, Frigidaire Corporation, *Detroit.*

RUGGLES, COL. COLDEN L'H., Ordnance Department, 2551 Munitions Building, *Washington.*

RYON, HERBERT C., service manager, Watson Products Corporation, *Canastota, N. Y.*

SALISBURY, C. D., chief engineer, Winton Engine Works, *Cleveland.*

SANDERSON, CLIFFORD W., chief chemist, Fisk Rubber Co., *Chicopee Falls, Mass.*

SCHABINGER, CHARLES H., engineer, Federal Motor Truck Co., *Detroit.*

SCHIRMER, WALDO P., vice-president, Schirmer Co., *Cleveland.*

SCHREIBER, KARL O., division superintendent, International Harvester Co., *Akron, Ohio.*

SCHWARTZ, HARRY A., metallurgical engineer, National Malleable Castings Co., *Cleveland.*

SCOTT, JOHN, assistant works manager, Olds Motor Works, *Lansing, Mich.*

SELKER, HARRY, president and general manager, Buckeye Brass & Mfg. Co., *Cleveland.*

SEVIN, FREDERIC W., engineer, Claudel Carburetor Co., *Detroit.*

SHIBLEY, WILLIAM A., secretary and treasurer, Southern Automobile Mfg. Co., Inc., *Memphis, Tenn.*

SLATER, R. J., experimental engineer, Chandler Motor Car Co., *Cleveland.*

SLOYAN, JEROME J., service engineer, General Ordnance Co., *Cedar Rapids, Iowa.*

SORENG, E. M., sales manager and consulting engineer, Briggs & Stratten Co., *Milwaukee.*

SPEER, JAMES K., designer, Pittsburgh Model Engine Co., *Pittsburgh.*

STAPLETON, MICHAEL F., Western sales manager, Marlin-Rockwell Corporation, *New Haven, Conn.*

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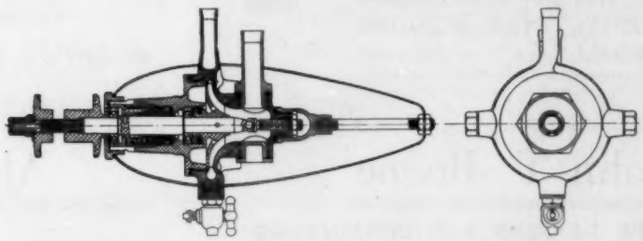

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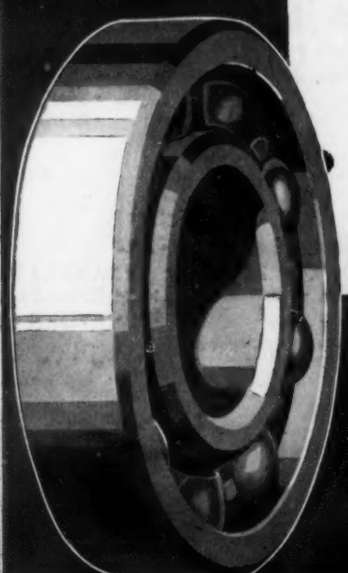

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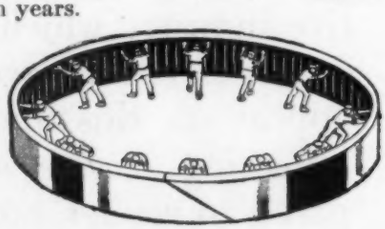

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Marine, Stationary, Tractor Engines and Pumps

STANDARD MOTOR CONSTRUCTION CO.
WORTHINGTON PUMP & MCHRY. CO.
NEW LONDON SHIP & ENGINE CO.
G. W. LATHROP ENGINE CO.
AMERICAN CLAY MACHINERY CO.
McINTOSH & SEYMOUR CORP.
EMERSON-BRANTINGHAM CO.
DE LA VERGNE MACHINE CO.
NEW YORK AIR BRAKE CO.
GRAY MOTOR COMPANY
MIANUS MOTOR WORKS
FULTON IRON WORKS
MIDWEST ENGINE CO.
GENERAL ELECTRIC CO.
WALLACE TRACTOR CO.
TABOR MFG. CO.
INGERSOLL-RAND

Airplane Engines

WRIGHT-MARTIN AIRCRAFT CORP.
PACKARD MOTOR CAR CO.
TREGO MOTOR CORP.
DUSENBERG & CO.

ORIGINAL HAMMERED

WASSON PISTON RING

WASSON PISTON RING CO.

Plainfield, N. J.

Master

ELECTRICAL PRIMER

on ***Franklin Cars***

Grace of line and beauty of finish are naturally expected in cars of recognized standing.

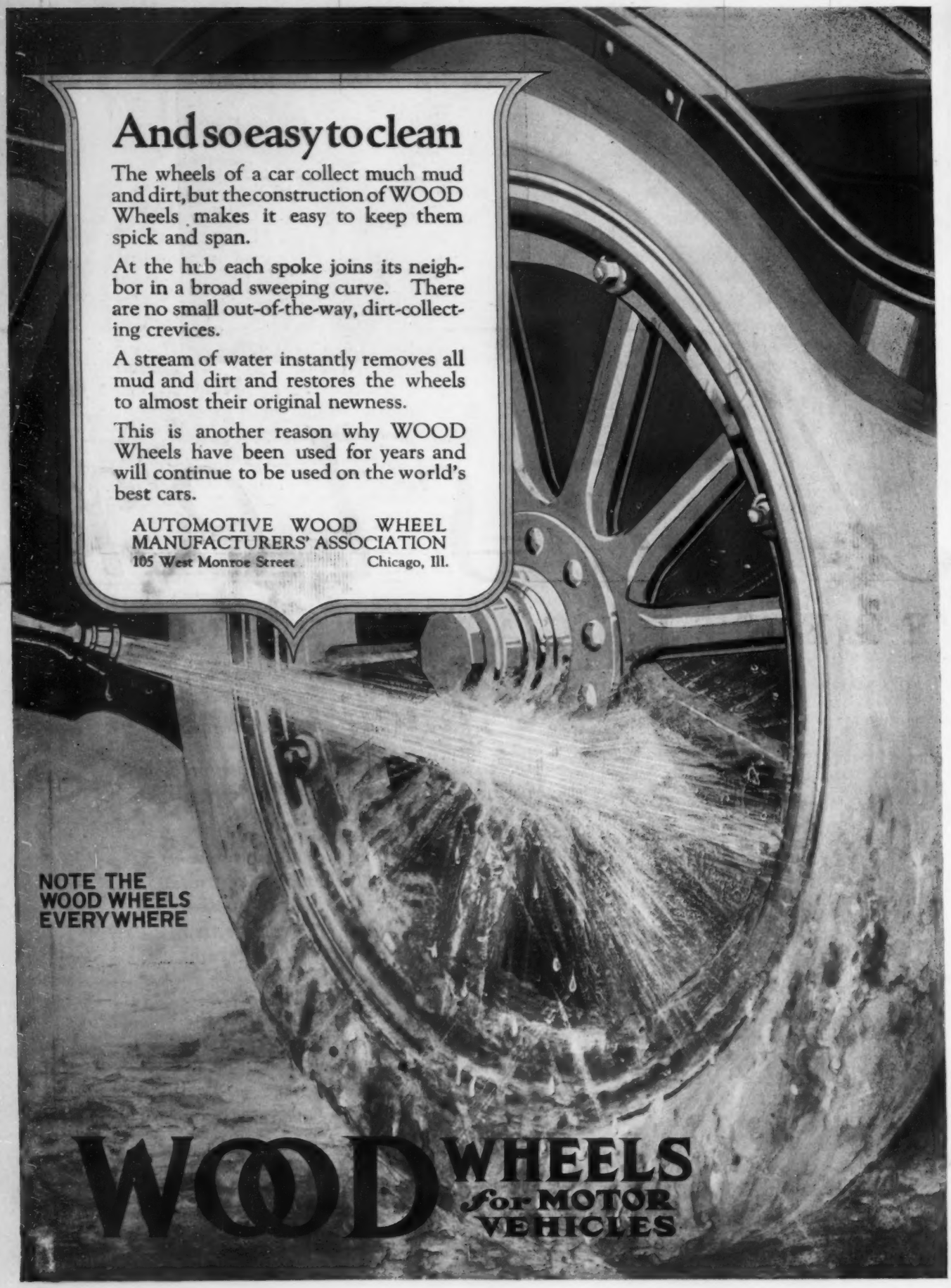
But in reality it is the added refinement of those mechanical controls which make a car sensitively responsive to the driver's will in all seasons that spells the difference between good and excellent performance.

It is such performance that has given the Franklin car its standing among automobiles. The Franklin is another of those quality cars having Master Electrical Primer as standard equipment.

Master Primer Company

34 E. Larned Street Detroit, Michigan

Standard Equipment on Quality Cars


And so easy to clean
The wheels of a car collect much mud and dirt, but the construction of WOOD Wheels makes it easy to keep them spick and span.
At the hub each spoke joins its neighbor in a broad sweeping curve. There are no small out-of-the-way, dirt-collecting crevices.
A stream of water instantly removes all mud and dirt and restores the wheels to almost their original newness.
This is another reason why WOOD Wheels have been used for years and will continue to be used on the world's best cars.
AUTOMOTIVE WOOD WHEEL MANUFACTURERS' ASSOCIATION
105 West Monroe Street Chicago, Ill.
NOTE THE WOOD WHEELS EVERYWHERE
WOOD WHEELS for MOTOR VEHICLES

The struggle to produce a means of multiplying POWER has continued for ages. Each era has added its quota to the sum total of POWER knowledge and achievement. Few needs have ever been greater than those of supplying Energy for the requirements of the human race. ¶ The builder of power-creating mechanism today, therefore, is confronted with an enormous obligation. Upon him rests the responsibility for the CONTINUED development of his product. ¶ The Continental Motors Corporation recognizes this obligation. It is manifested in the Continental organization and in the Continental product. It is one of the factors that guarantees to the manufacturer of Continental equipped cars and trucks and tractors, the MAINTENANCE of the quality standards that have always been associated with the Continental Red Seal.

CONTINENTAL MOTORS CORPORATION

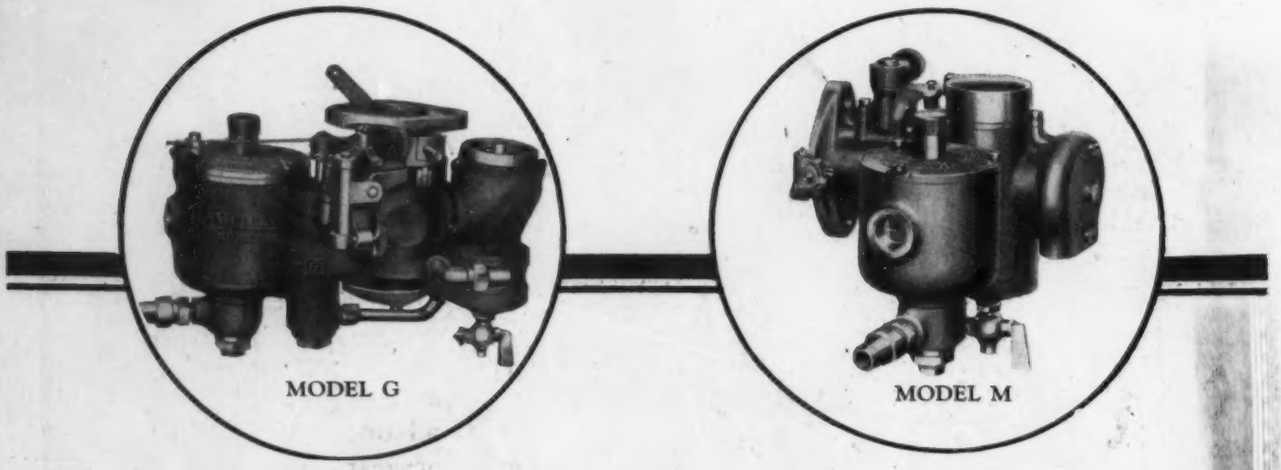
Offices: Detroit, U. S. A. Factories: Detroit and Muskegon

Largest Exclusive Motor Manufacturers in the World

Continental Motors

STANDARD POWER FOR TRUCKS, AUTOMOBILES AND TRACTORS

Rayfield Carburetors Develop the Power Built into Your Motor



Correct in principle and design, the Rayfield Carburetor starts the motor easily, permits fast, smooth acceleration from any speed, idles the motor perfectly, and develops the maximum power at low cost.

Manufacturers of many of America's best motor cars have found that Rayfield Carburetors best develop the power built into their motors.

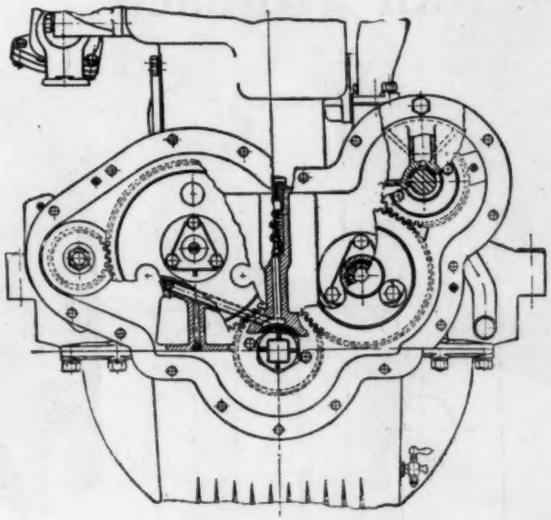
This has been proved by actual tests on many types of motors.

The better performance obtained with Rayfield Carburetors gives greater satisfaction to the owner.

It is the realization of this fact which has led so many manufacturers to adopt Rayfield as standard equipment.

BENEKE & KROPF MANUFACTURING CO.
2559 West 21st St., Chicago, Illinois

RAYFIELD CARBURETORS



THE Buda engine gear set includes one crank, one cam, one idler, and one pump shaft gear; also one generator gear when a lighting unit is used. Easy access to all gears is possible by merely removing the gear case cover.

Wide-faced timing gears are helically cut to the proper angle on special automatic hobbing machines which insure interchangeability.

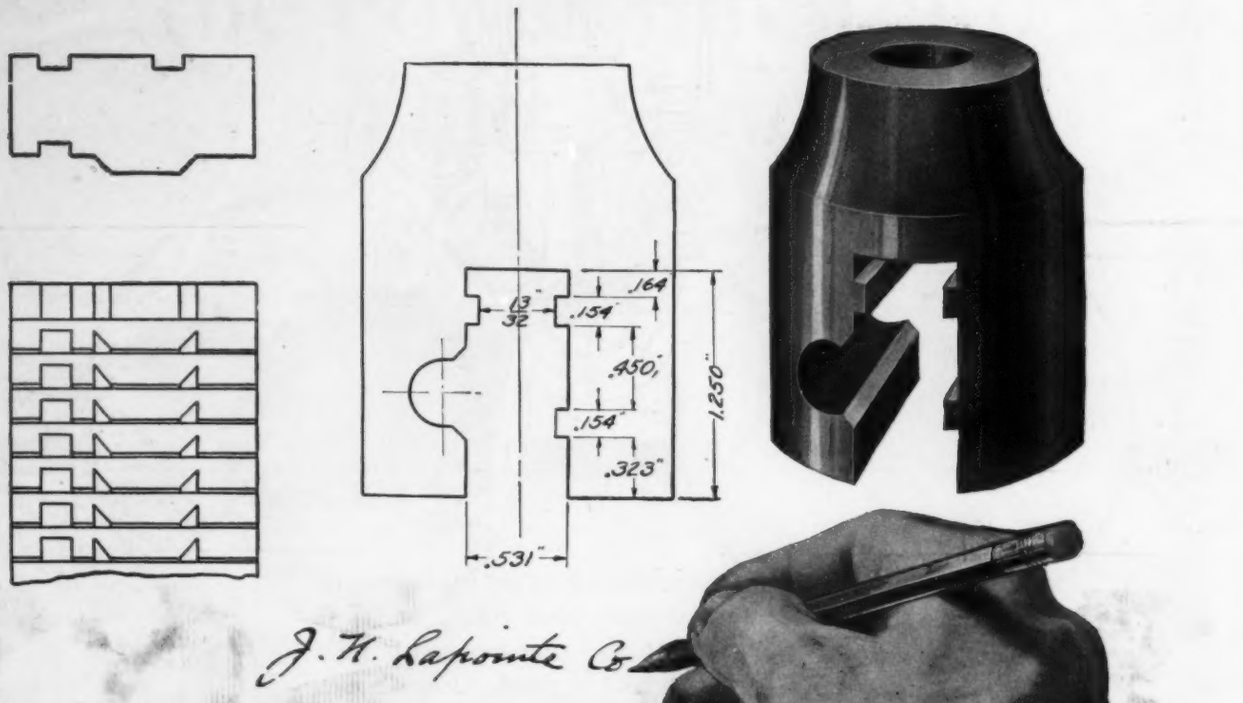
Fine attention, too, is given to provide accurate gear centers, the idler gear being mounted upon an adjustable bearing to assist in this achievement.

Through these Buda refinements is gained the exceptionally quiet gear operation at all speeds that contributes essentially to the mechanical goodness of the Buda engine.

THE BUDA COMPANY, HARVEY CHICAGO SUBURB ILL.
ESTABLISHED 1881

BUDA
The
ENGINE

"0.001 inch clearances by an apprentice—with a broach"



Deep cuts in a sliding piece double keyed and fitting to the thousandth of an inch ordinarily would take time and an expert workman. Yet with the proper broach even an apprentice can turn out flawless and exactly interchangeable work in a tenth of the time of milling.

It is because of this from the facility it gives the manufacturer of small duplicate pieces to increase production without affecting the payroll that broaching has grown steadily into favor throughout the country.

Cutting difficult or unusual pieces correctly and rapidly by a workman only experienced enough to start and stop the machine—that's the great aid to greater production afforded by the broaches and broaching machines made by the

Representative for Great Britain:
Charles Churchill & Co., Ltd.,
9-15 Leonard St., Finsbury,
London, E. C.

Representatives for Great
Fenwick Freres
8 Rue de Rocroy
Paris

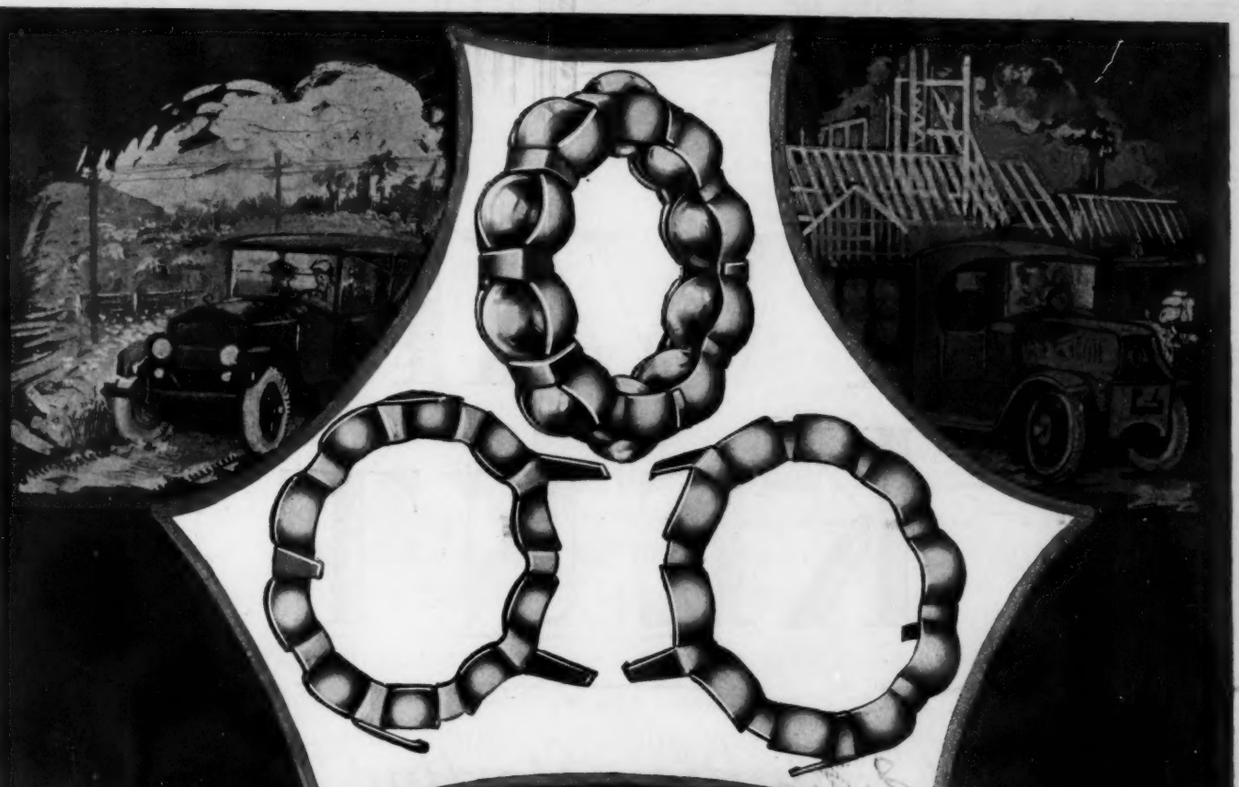
Representative for Italy:
Selson Engineering Co.,
Milano

J.N. LAPOINTE CO.
OF NEW LONDON, CONN.

DETROIT OFFICE: 11 HARPER AVE.

2059-L

Makers of Broaching Machines and Broaches.



FAFNIR

A FAFNIR FEATURE

An exclusive feature of *Fafnir Ball Bearings* is to be had in the design and construction of the *Fafnir Patented Pressed Steel Ball Retainer* illustrated above. We would call attention to the following points of superiority:

(1) The steel fingers which hold the retainer together cross above the pitch line of the balls, permitting the assembly of *more* and *bigger* balls.

(2) The balls are guided at their *rotating axes*, resulting in a practically frictionless retainer.

(3) There are no screws or rivets to become loose.

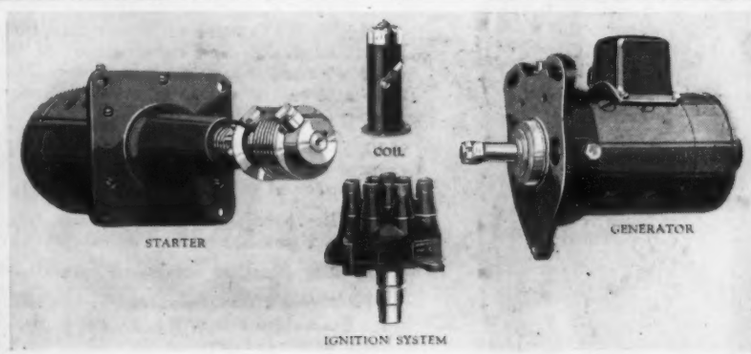
(4) The Fafnir Retainer is flexible and resilient rather than rigid. It will conform to the ball curvature and will withstand severe shock or strain without danger of fracture.

The Fafnir Bearing Company
Conrad Patent Licensee
New Britain, Conn.

DETROIT Office: 752 David Whitney Bldg.
CHICAGO Office: 1301 Michigan Ave.
CLEVELAND Office: 916-917 Swetland Bldg.

ATWATER KENT

Ignition, Starting and Lighting



A T W A T E R K E N T

WAYNE JUNCTION

ATWATER KENT products can be classed among those sterling articles of commerce that have ceased to need the qualifying help of adjectives to arouse enthusiasm in their favor.

Quality of product and performance over a long period of time has built an appreciation that amply protects the good name of Atwater Kent products and assures continued and increasing use.

Atwater Kent equipment is now used by more than twenty-five of America's foremost manufacturers of motor cars.

MFG. COMPANY

PHILADELPHIA

BOSCH MAGNETO

That Sale You Missed

We forget the sales we lose and remember the ones we make. That's human.

But let's analyze the last one you lost. You tried to sell your car, unit by unit, using each part, every sales argument you could build, and still the prospect wasn't satisfied. You needed one last argument that would satisfy him beyond all question that you had a thoroughly reliable car.

That's where Bosch Magneto Ignition would have won his confidence and "clinched" the sale. For every one knows that Bosch Magnetos are thoroughly dependable and that engines equipped with them develop utmost power, full efficiency and greatest economy.

Three million users vouch for Bosch Ignition. Four million will do it next year.

Be Satisfied
Specify Bosch

300 Service Stations in 300 Centers

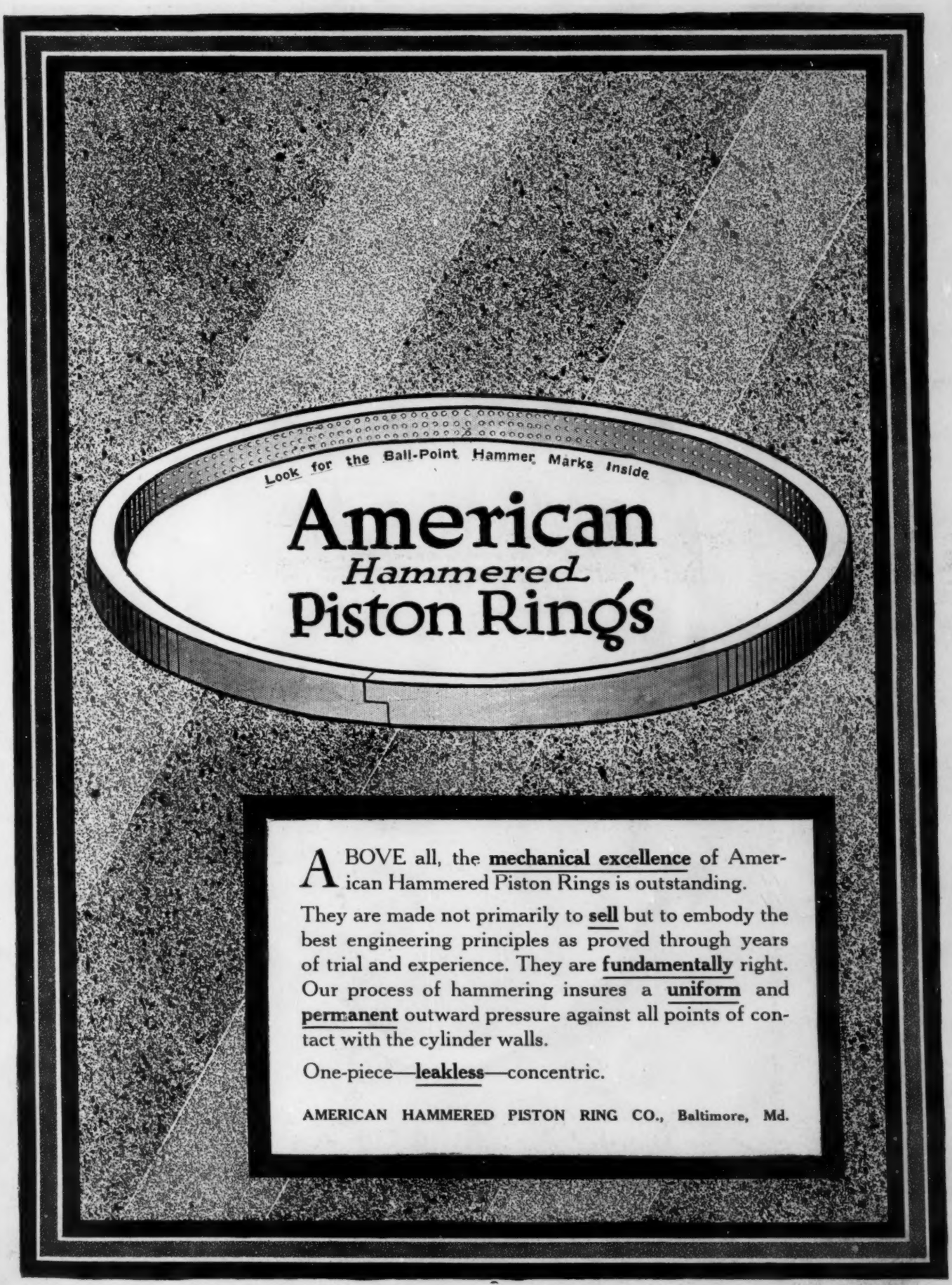
AMERICAN BOSCH MAGNETO CORPORATION

Main Office and Works: Springfield, Mass.

Branches: New York, Chicago, Detroit, San Francisco

AMERICA'S SUPREME IGNITION SYSTEM

MOTOR TRUCKS – TRACTORS – AIRPLANES – MOTOR CARS – MOTOR BOATS – MOTORCYCLES – GAS ENGINES – ETC.



ABOVE all, the **mechanical excellence** of American Hammered Piston Rings is outstanding.

They are made not primarily to **sell** but to embody the best engineering principles as proved through years of trial and experience. They are **fundamentally** right. Our process of hammering insures a **uniform** and **permanent** outward pressure against all points of contact with the cylinder walls.

One-piece—**leakless**—concentric.

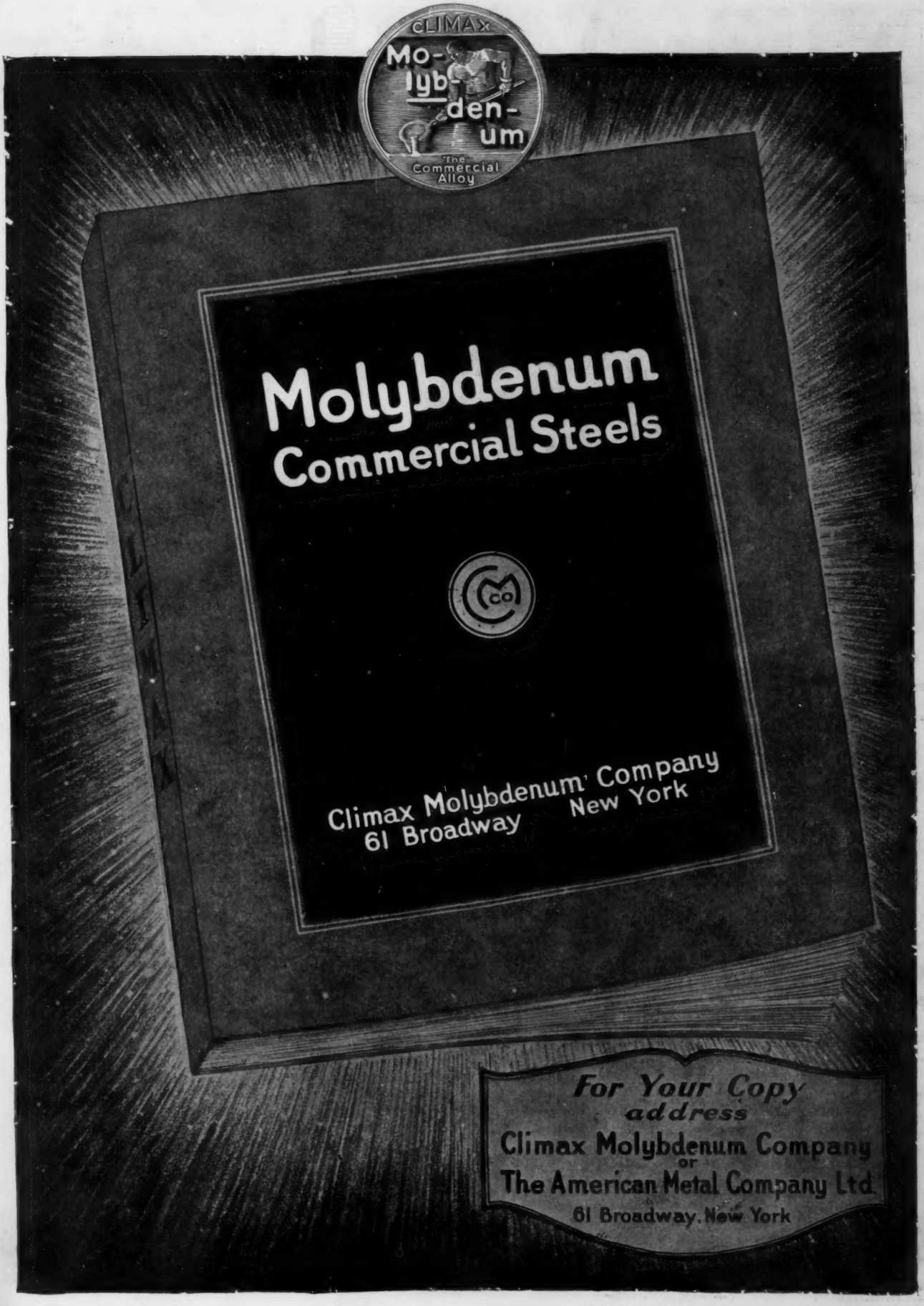
AMERICAN HAMMERED PISTON RING CO., Baltimore, Md.

"More Than a Million a Month"

QUALITY
SNAP RINGS

PREDOMINATE

THE Piston RING COMPANY
MUSKEGON, MICH.


CLIMAX
Mo-
lyb-
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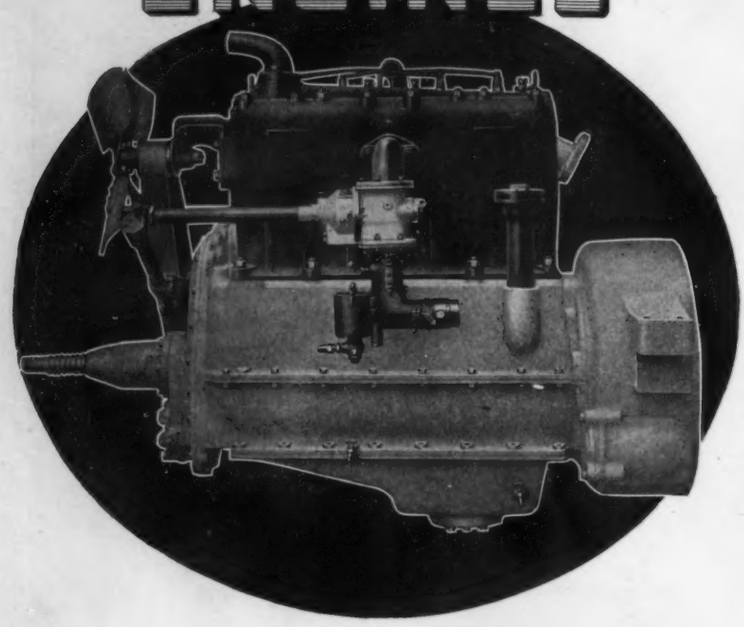
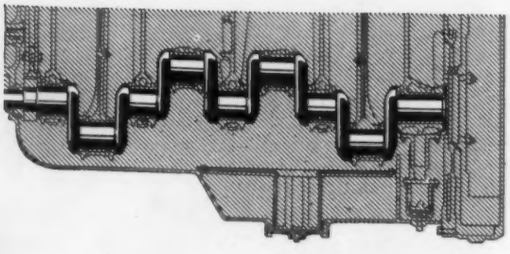
um
The Commercial Alloy
Molybdenum
Commercial Steels
CLIMAX
Climax Molybdenum Company
61 Broadway New York
For Your Copy
address
Climax Molybdenum Company
or
The American Metal Company Ltd
61 Broadway, New York

HERCULES
ENGINES





The Factor of Safety

Ample bearing surfaces; a sturdy crankshaft; positive lubrication; copious water spaces around the cylinder heads: in fact *every* detail of Hercules Engines has been designed to provide such a large factor of safety that it will be indifferent to the severest strains of heavy duty.

For the manufacturer who equips his product with Hercules Engines there is also the safety factor of dealing with a well-rounded, smooth-functioning organization of men experienced in engine building.

A Crankshaft With 5 Main Bearings—

—eliminates deflection through the rigid support of a main bearing on each side of every crank pin.

—gives almost endless life of bearings.

—insures such perfect balance that periodic vibrations are eliminated.

—transmits all the generated power into actual driving effort.

The Hercules Motor Mfg. Company
Canton, Ohio

Sales Offices: Detroit Chicago Buffalo
San Francisco London, England

FOR TRUCKS AND TRACTORS

The Truck Wheel That Reduces Operating Costs

Reduce your motor truck operating costs by equipping your trucks with Jaxon Full Floating Wheels.

The six rubber cushions within these wheels absorb the road shocks and vibrations so damaging to the working parts of the truck.

And by so reducing the destructive vibration Jaxon Full Floating Wheels eliminate a great proportion of mechanical repairs due to the wear and loosening of parts.

Your truck equipped with Jaxon Full Floating Wheels will cost less to maintain, can be in operation a much greater portion of the time and will be capable of increased hauling area.

The increased tire mileage and fuel economy resulting from the use of Jaxon Full Floating Wheels has been a matter of comment among Jaxon users.

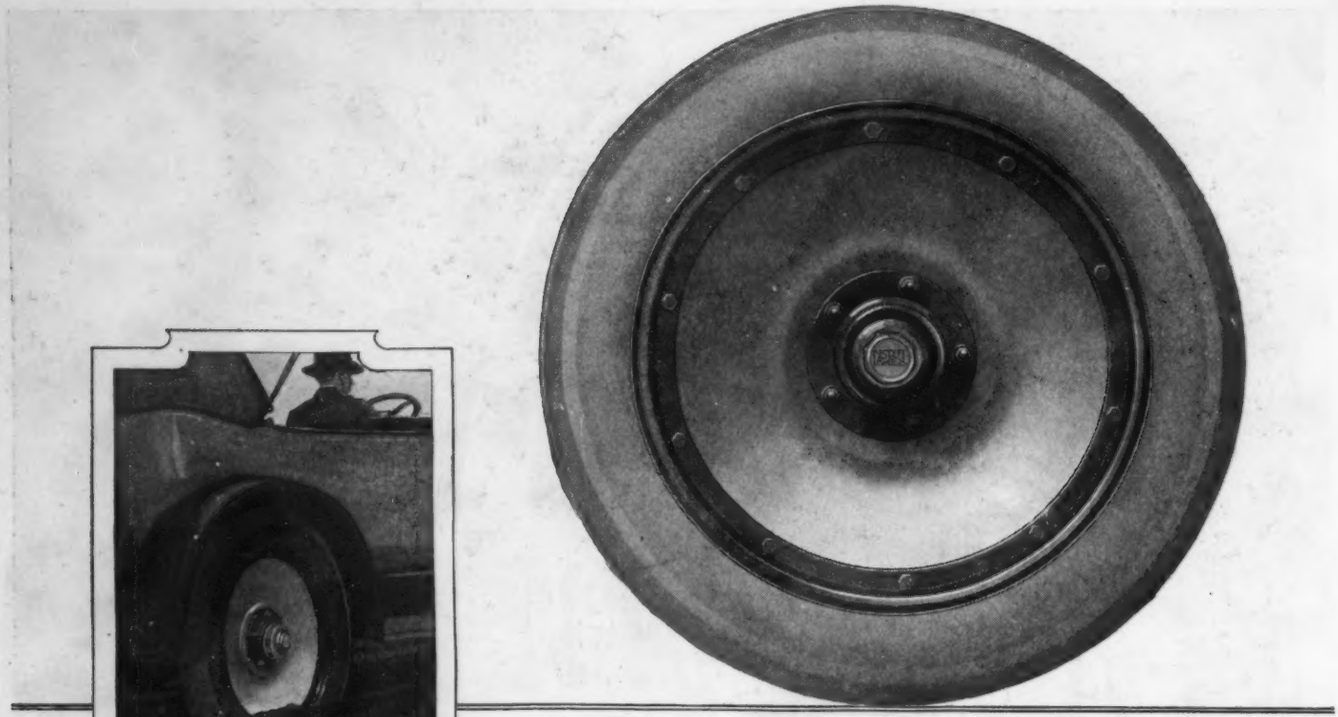
Reduced operating costs and greater earnings. That's what Jaxon Full Floating Wheels mean to truck owners.

Jaxon Steel Products Company

Jackson *Department M-7* Michigan

JAXON

FULL FLOATING WHEELS



Facts You Should Know About the Wheels of Your Motor Car

Wheel-Talk Number Five

What do YOU know about the Wheels of your Motor Car? Do YOU know how the modern Wheel is designed and constructed; how it has simplified tire-changing and wheel-changing; how it adds to your safety, convenience and economy; how it conserves gasoline and tires; how it cuts through mud and sand; how it prolongs the life of the car?

There is nothing extraordinary in these features. They are accomplished merely by bringing Science, modern engineering Science, to the Wheels of the Motor Car. That is the purpose of these Wheel-Talks —to tell you what you can reasonably demand of the Wheels of your Motor Car.

These Wheel-Talks are now published in book form and will be sent upon request.

A Wheel should cut the rut—like a knife, and leave the mud behind—as a knife would leave it. It is a simple truth of mechanics and economy.

This is almost too obvious to require explanation. A Wheel that picks up the mud, "cages" it—and carries it along, retards the car, over-works the motor and wastes just that much time, power and gasoline. Sand, clay and snow, too, hold back the Wheel that offers a resisting surface.

The frozen rut, too, presents a wheel-problem. It wracks and strains the Wheel —with side thrusts.

The Wheels on your Motor Car should be so designed that they keep the tires exactly 56 inches apart from center to center. This is standard practice in Automobile Engineering.

The Wheel that fails to maintain this standard tread of 56 inches throws the tire out against the sides of the rut and subjects it to needless bruising and laceration.

The Disteel Wheel is a single, tapered disc of steel—all steel—one piece of steel. It is easily cleaned. It is very light, and, at the same time, the strongest wheel in the world. It holds the tire true and firm. It cuts cleanly through mud, snow and sand. It offers the minimum resistance.

We want you to see more than the vastly greater beauty that Disteel Wheels bring to the motor car. We want you to comprehend the simple, scientific principles upon which Disteel Wheels are designed and because of which Disteel Wheels are adding immeasurably to the safety, economy and ease of modern motoring.

Exclusive Manufacturers

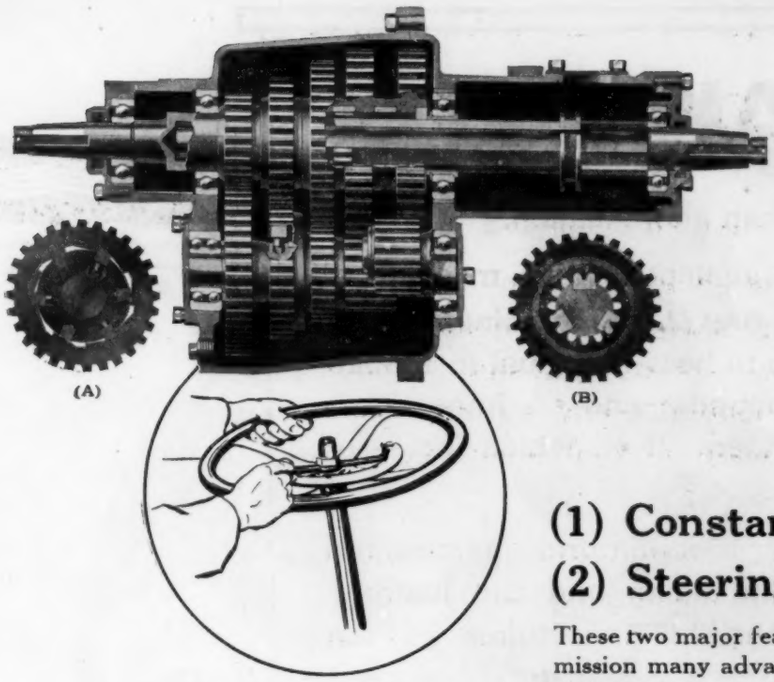
Detroit Pressed Steel Company, Detroit, U. S. A.

Disteel Wheel Plant, Cabot Avenue
New York: 1846 Broadway at 61st St.
Boston: 925 Boylston Street

Automobile Frame Plant, Mt. Elliott Avenue
Chicago: 732 Michigan Ave.
San Francisco: 326 Rialto Building

DISTEEL WHEELS

The Wheels That Complete The Car



(A) Full-floating action of dog clutch eliminates "jerking" when changing from high to a lower speed.

(B) Cross section of main drive shaft, showing sliding key construction which controls speed selection.

Blue prints, literature and test sets on request to manufacturers of motor cars and motor trucks.

(1) Constant-Mesh Gears
(2) Steering-Post Control

These two major features give the Power-Rite Transmission many advantages over transmissions of the older type.

Because its gears are constantly in mesh, the Power-Rite entirely eliminates gear shifting. And, for the same reason, it does away with the burring and stripping which so frequently results from the shifting of gears.

Speed changes are effected with remarkable swiftness by a simple lever-control on the steering post—a feature which also adds greatly to the ease and safety of driving, especially in congested traffic.

Through simplified construction the Power-Rite reduces transmission weight by approximately 25%, besides making all working parts readily accessible.

These and other advantages—notably stamina, strength and quietness of operation—have won for the Power-Rite the approval of leading engineers in the automotive industry. A long series of tests has proven the Power-Rite a practical as well as a superior type of transmission for both motor cars and motor trucks.

The Detroit Transmission Company

166 Lycaste Avenue **Detroit, Michigan**

POWER-RITE
"The Right Power at the Right Time"
TRANSMISSION

BAKELITE

REG. U. S. PAT. OFF.

—more than an insulation.

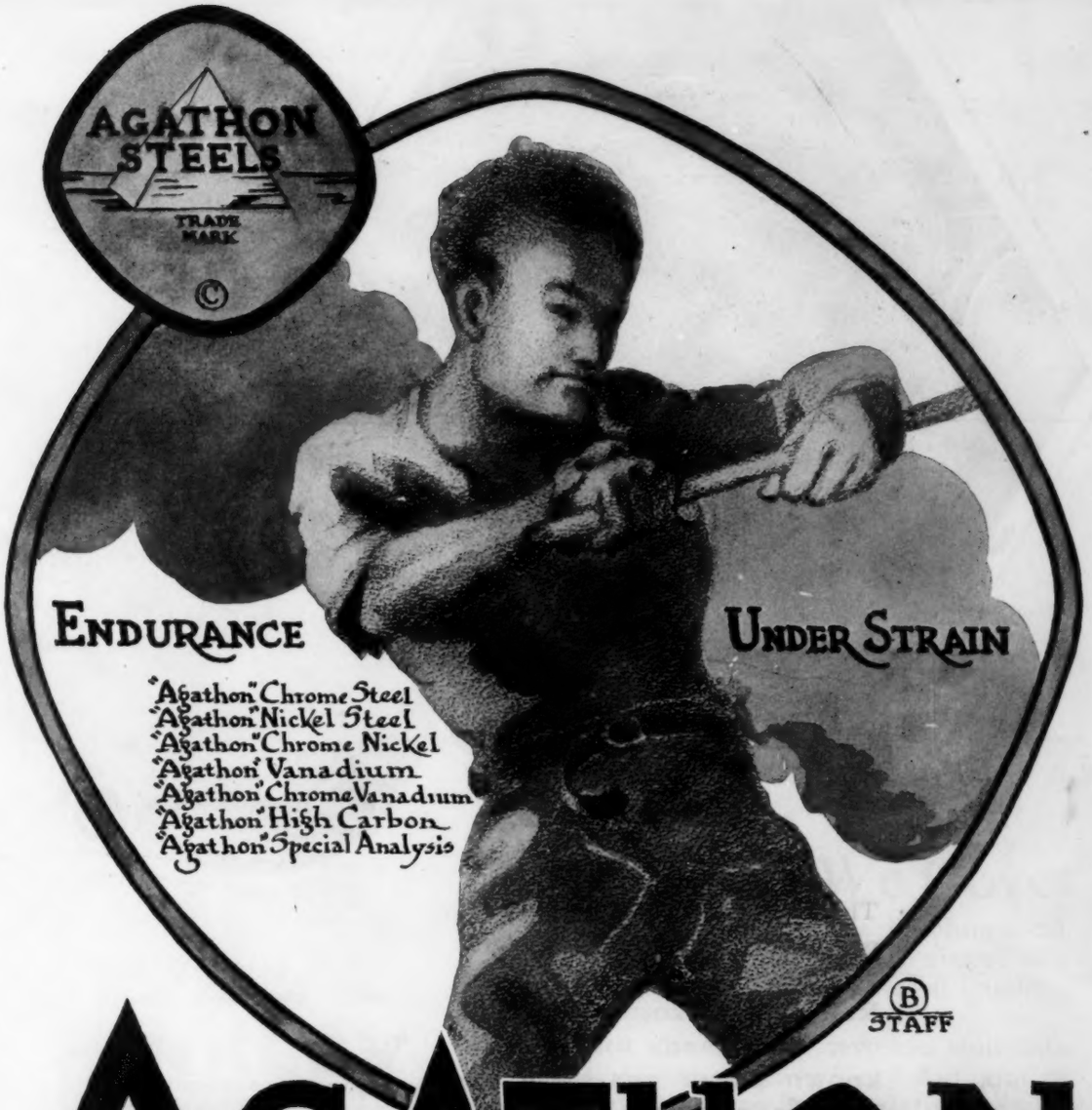
With its dielectric and mechanical strength, **BAKELITE** combines a high resistance to heat—unusual in moulding compounds—and an imperviousness to water and oil which increases its normal life.

In addition to its natural qualities, the accurate moulding and the lustrous surface **BAKELITE** acquires in the moulding process save any subsequent hand-finishing and make moulding with **BAKELITE** preferable from a manufacturing as well an an engineering point of view.

GENERAL BAKELITE COMPANY
TWO RECTOR STREET
NEW YORK

An instrument top with moulded holes. Notice the clean bores, smooth edges and sharply defined indentations.

2062-B



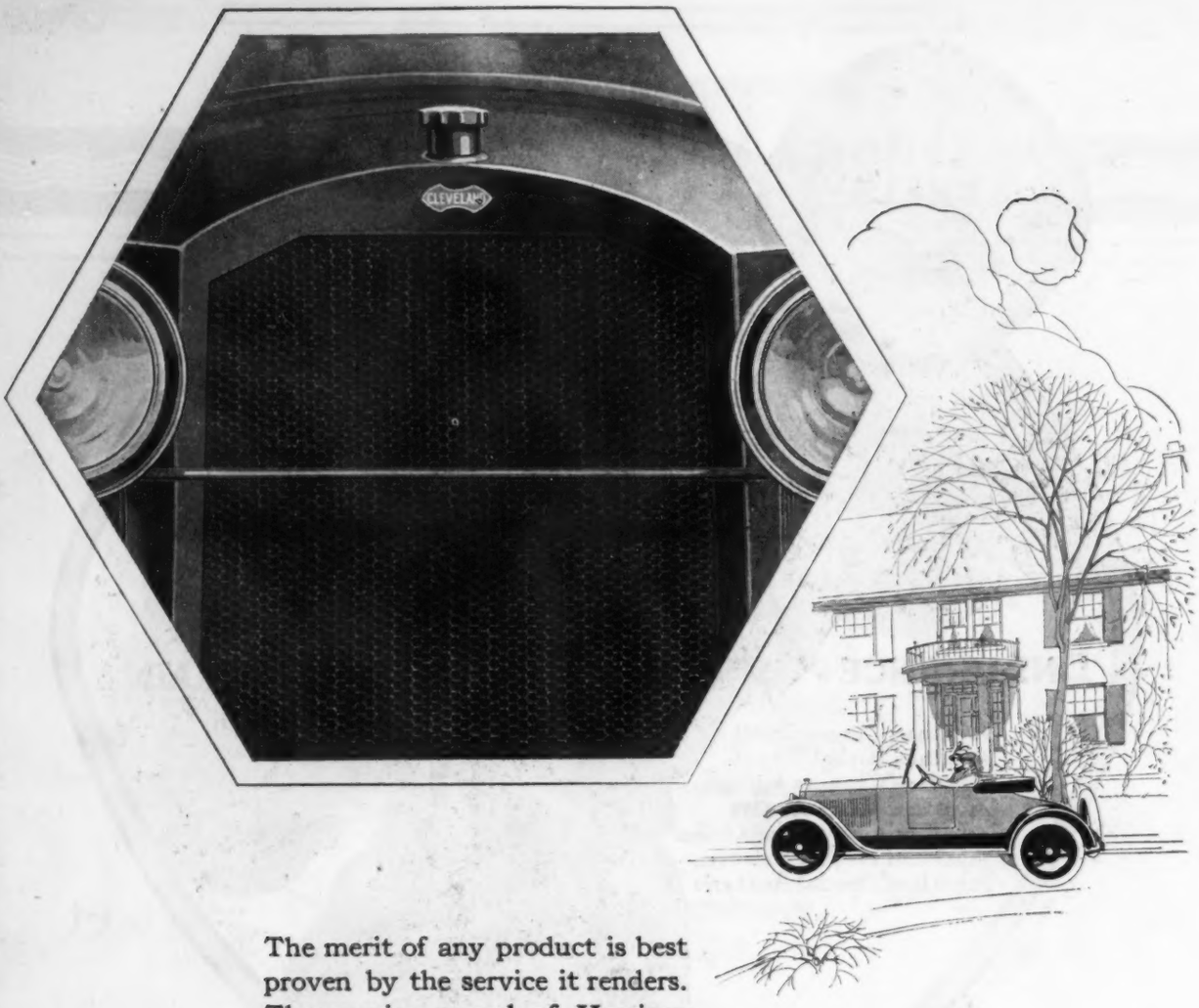
AGATHON
ALLOY STEELS

Branch Offices:
Cleveland, *Hickox Building, The Hamill Hickox Co., District Representatives.*
Chicago, 1370 *Peoples Gas Bldg., 122 S. Michigan Blvd., C. H. Beach, District Sales Manager.*

Physical perfection, strength and endurance under unusual strains have won for Agathon alloy steels a worldwide recognition as the standard of quality.

The Central Steel Company
Massillon, Ohio
Export Dept., 20 *Broad St., New York City*

Branch Offices:
Detroit, *Book Building, Arthur Schaeffer, District Sales Manager.*
Philadelphia, 603 *Widener Bldg., Frank Wallace, District Sales Manager.*
Syracuse, 621 *University Block. T. B. Davis, District Sales Manager.*

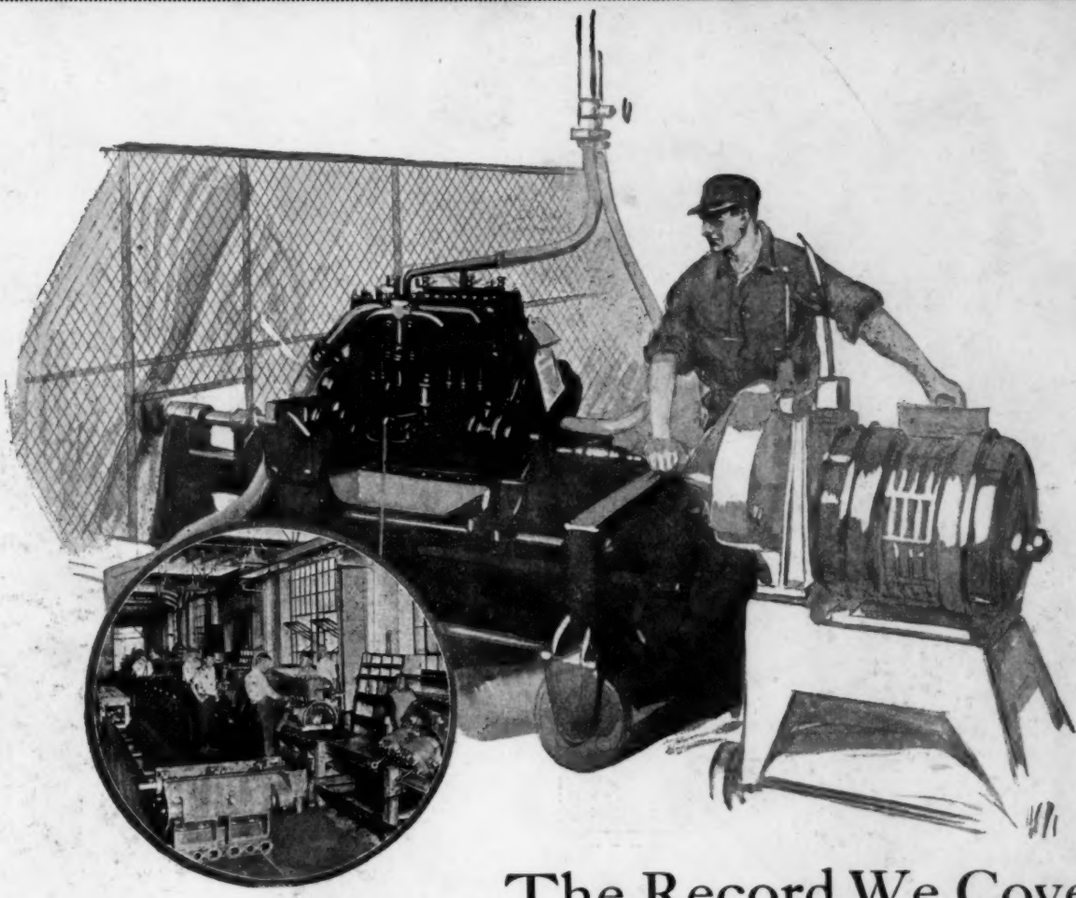


The merit of any product is best proven by the service it renders. The service record of Harrison Radiators is known the world over. The many universally known motor cars which are Harrison equipped have effectively demonstrated the uniform high quality of Harrison performance. The Cleveland is another Harrison equipped motor car.

HARRISON RADIATOR CORPORATION

General Offices and Factory · Lockport, N. Y.
General Sales Offices · Detroit, Michigan

HARRISON *Original Hexagon Cellular* Radiators



The Record We Covet

To establish new records in Numerical Production of Engines is not the aim of this Corporation. Our strife is toward Quality, not Quantity.

We have, therefore, undertaken contracts to supply Hinkley Heavy Duty Automotive Engines this year to but a relatively small number of Truck Manufacturers.

These Truck Manufacturers are among the established Leaders. The other units of their product have naturally been chosen with similar regard for highest quality and performance in Mechanical Transport.

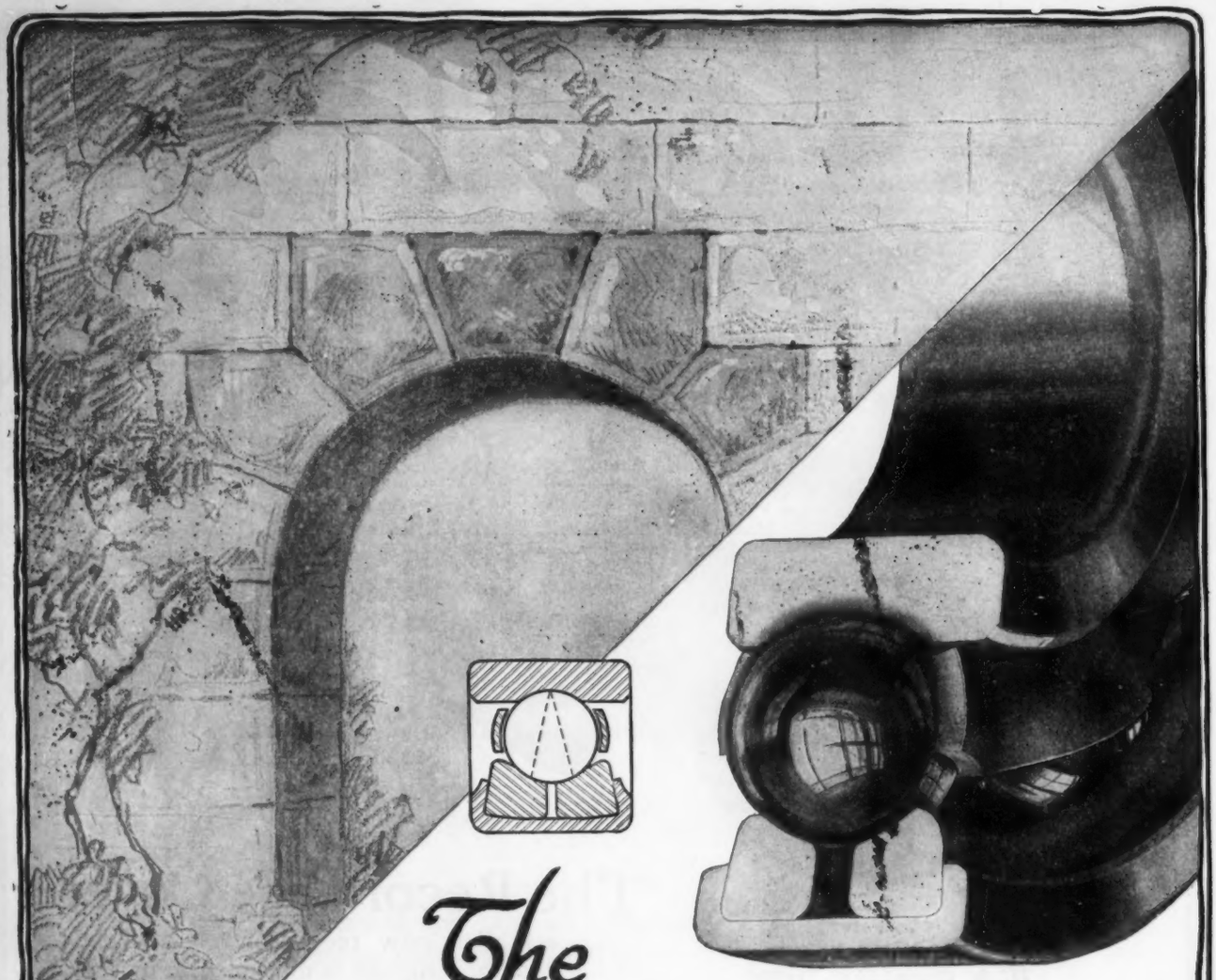
You can be sure, therefore, that a Hinkley-Engined Truck will live up to every reasonable claim made by the man who asks you to buy it.

High Quality Motor Trucks Equipped with

HINKLEY
HEAVY DUTY AUTOMOTIVE
ENGINES

are on sale everywhere. Ask us for a complete list of these trucks with their respective ratings.

HINKLEY MOTORS CORPORATION
Detroit



The Keystone Applied

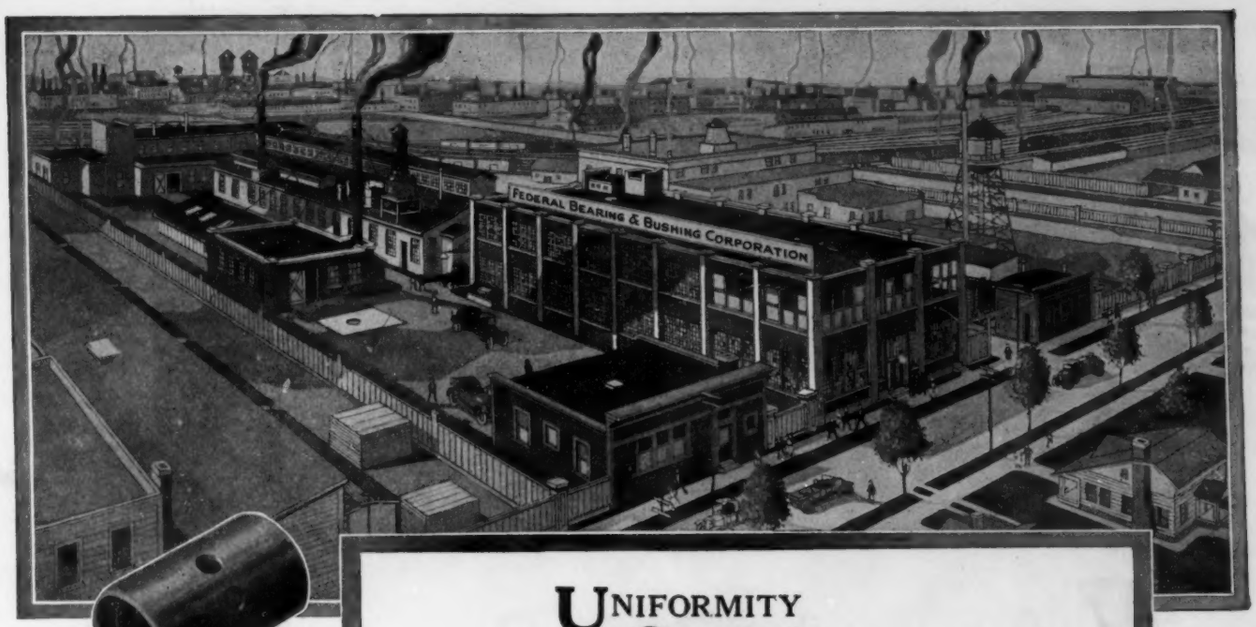
Wherever man has builded, the principle of the keystone is recognized. The Schatz Universal Annular Ball Bearing is its application to a modern problem. The weight of the load is divided and distributed. Crushing, direct-through-the-center blows are impossible.

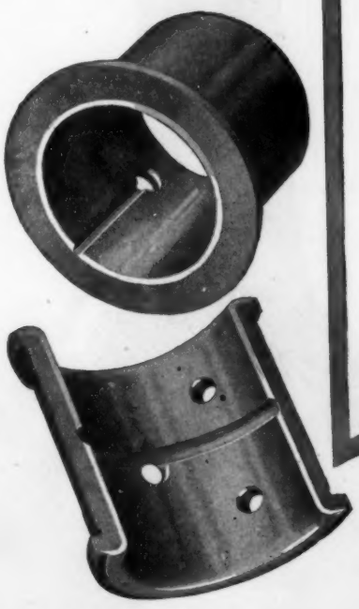
Schatz UNIVERSAL Annular BALL BEARING

Specify the bearing with a margin of safety—Schatz Universal.

THE FEDERAL BEARINGS CO., Inc.
Poughkeepsie, N. Y.

Great Britain: 37 Sheen Road, Richmond, London





UNIFORMITY
SOLIDITY
EXCELLENCE

FEDERAL BEARINGS

WHY does every Federal Bearing show the same tough, fine grained homogeneous structure in the fracture of the Babbitt lining?

BECAUSE every Bearing is chilled immediately after it is lined. That is UNIFORMITY.

WHY is every Federal Bearing guaranteed absolutely free from porosity?

BECAUSE the process of manufacture makes it impossible for the Babbitt to contain air while cooling. That is SOLIDITY.

WHY is every Federal Bearing manufactured from the highest grade materials, machined accurately and subjected to the most rigid inspection?

BECAUSE "FEDERAL, DETROIT" must be stamped on the back. That is EXCELLENCE.

What Is Our Secret?

CENTRIFUGAL FORCE

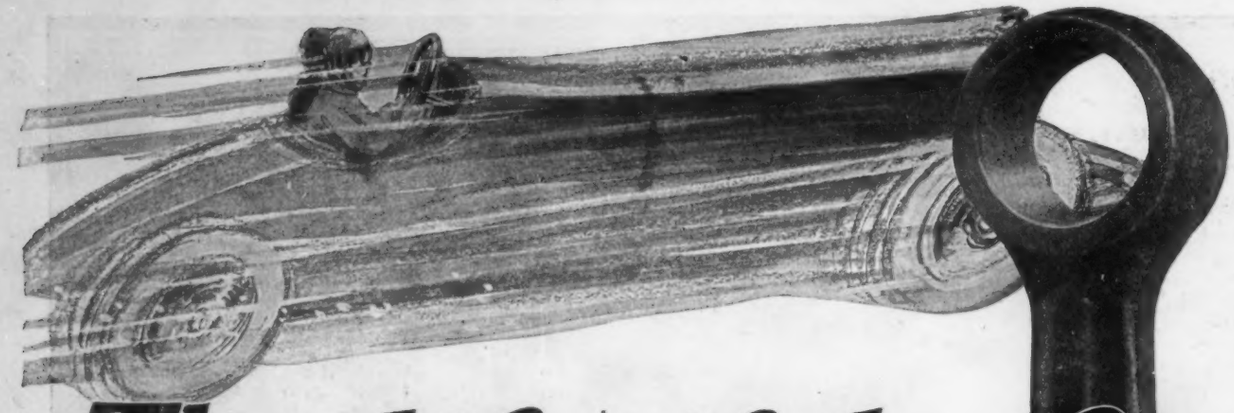
(Process protected by patents)

THINK

FEDERAL BEARING & BUSHING CORPORATION

BABBITT-LINED BRONZE-BACK BEARINGS_BRONZE BUSHINGS_BRONZE CASTINGS

DETROIT — MICHIGAN



The life of the Car—

LAMINUM

No part of the engine is more vital to service and satisfaction than the bearings. Nothing will contribute so directly to the life of the bearings as the accurate adjustment made possible by laminated shims. They are of Laminum, thin layers of brass held together by a metallic binder like solder. These layers are peeled off easily and quickly with a knife blade.

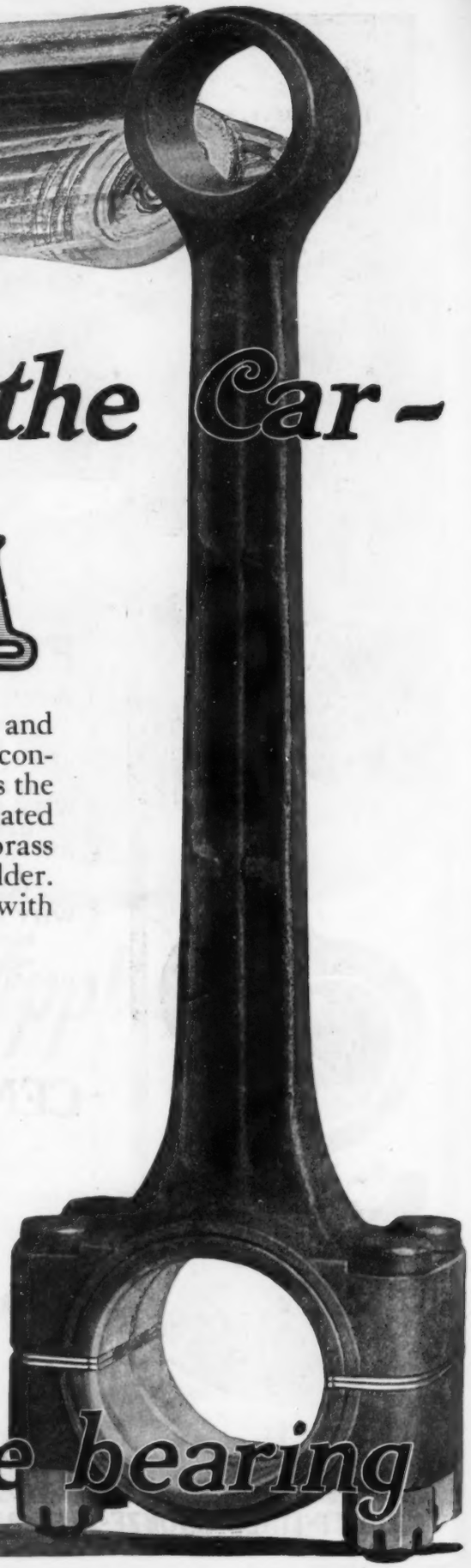
Shims of Laminum are furnished babbitt-faced if desired, to make an all babbitt bearing.

Laminated Shim Company

47 West 34th St., New York

DETROIT: Dime Bank Bldg. **ST. LOUIS: Mazura Mfg. Co.**

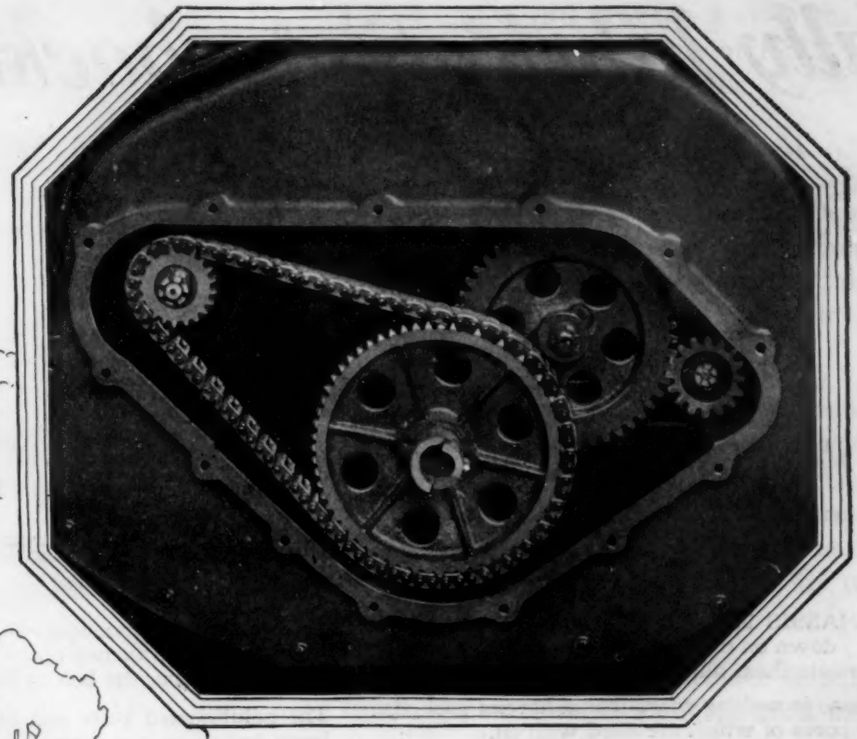
ENGLAND: R. A. Rothermel, 24-26 Maddox St.; Regent St., London, W. I.



The life of the bearing

HOLMES
Improved Air Cooled

uses the Link-Belt
Silent Chain Drive



WE offer our services in assisting designers and builders of automobile motors, on layouts involving the use of Link-Belt Silent Chain Drives for all functions on automobile engines. Our broad engineering experience in designing drives for this work, covers years of exhaustive experiment, and successful application of Silent Chains.

458 LINK-BELT COMPANY

PHILADELPHIA
Hunting Park Ave. and
P. & R. Ry.

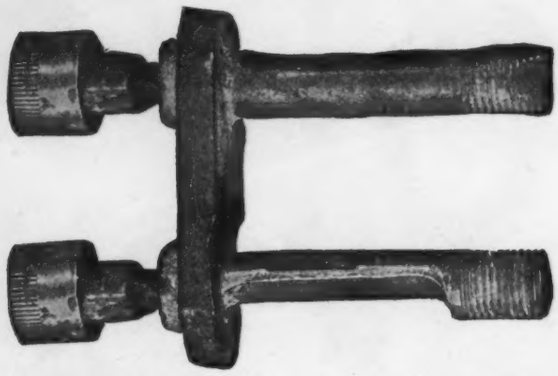
INDIANAPOLIS
W. Michigan St. and
Holmes Ave.

DETROIT
790 Woodward Ave.

LINK-BELT
SILENT CHAIN DRIVES

Really lubricating shackle-bolts

A shackle bolt worn out because of the inability of grease to lubricate all the way 'round. Wear like this causes bumpy riding and broken springs.



Madison Kipp

CHASSIS bolts of all sorts squeak, and wear down on one side because grease fails to lubricate them all the way round.

Grease is nothing more than a fibrous sponge, the pores of which are filled with oil.

When the oil has been squeezed out, the spongy part has no lubricating power. It gums and cakes shackle bolts and steering knuckles, and clogs their drill holes.

Then the fresh grease that you try to force to them, oozes out from under the grease-cup cap when the cup is turned down, and never gets to, or all around, the bolt or bearing.

The unlubricated bolts and steering knuckles begin to squeak and wear down.

What these parts of your chassis need is oil —*heavy oil*—that is *shot* to where it is needed—*shot* with Oil-Kipps—*shot* so forcefully that it spreads immediately all over the bearing surfaces.

Three Minutes Versus Thirty

Ordinary grease cups can be replaced with Oil-Kipps *without removing the bolts that need better lubrication.* Convenient Kipp-Adapters make it easy to install Oil-Kipps on any car or truck.

When your car is equipped with Oil-Kipps it requires only about three minutes to lubricate steering gear and shackle bolts.

You just walk around the car, and snap every Oil-Kipp once or twice.

With grease it would take about thirty minutes to attempt to do the job.

Not only do *Oil-Kipps* do it faster, but they do it much more neatly—and really do it.

By means of specially developed Kipp-Adapters, Oil-Kipps can be quickly applied to any make and model of car or truck.

Write for our dealer proposition.

MADISON-KIPP CORPORATION
MADISON, WISCONSIN

Model "K" Oil-Kipp for Shackle bolts and other horizontal positions.

Oil-Kipps

Model "H" Oil-Kipp for steering knuckles, clutches and other vertical positions.

KEEP CARS NEW

FOR truck and tractor service the continuous fin tubular type of radiator core is unreservedly favored by the McCord engineering department.

Summed up, the reasons are that this type of core possesses tremendous strength, resistance to blows, light weight, provides unimpeded circulation of large volume of air, thorough dissipation of heat and is easy to repair in case of accident.

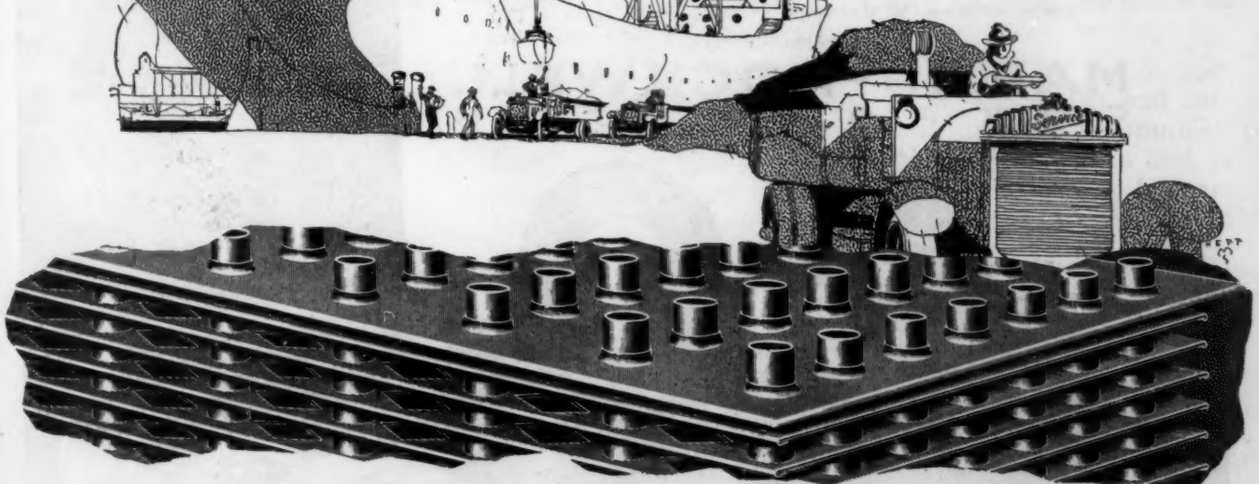
Years of experience and exhaustive tests of all types of radiators furnish unquestionable evidence of its superiority. While all types of radiators, both tubular and cellular, are manufactured by this company, there is no hesitancy in recommending the continuous fin tubular type for trucks and tractors.

We have in stock, for immediate shipment in limited quantities without pattern expense, standard designs of radiators to meet almost any requirement for trucks and tractors.

Service Stations: New York, 1926 Broadway
Chicago, 1512 S. Michigan Ave.

McCord Manufacturing Co., Inc.
Detroit, Michigan

Manufacturers of McCord Gaskets and McCord Force-Feed Lubricators



McCord
RADIATORS

MR MARLIN-ROCKWELL INDUSTRIES MR

SRB

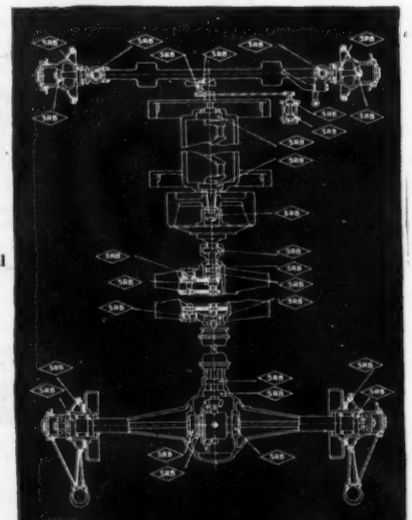
Single Row Double Row

ANNULAR BALL BEARINGS

BALL Bearings must be of finer steel, more accurately machined and capable of more critical duty than any other part of an automobile, truck, tractor or other mechanism demanding anti-friction bearings. Yet they do their work hidden away from sight; they must serve without attention or adjustment, yet be permanently proof against failure.

All the more reason why manufacturers of automobiles, trucks and tractors should use bearings of S. R. B. quality.

S. R. B. Ball Bearings and S. R. B. Taper Roller Bearings are used in those motor cars, trucks and tractors, whose names are instantly thought of as leaders in their respective fields.



STANDARD STEEL AND BEARINGS INCORPORATED

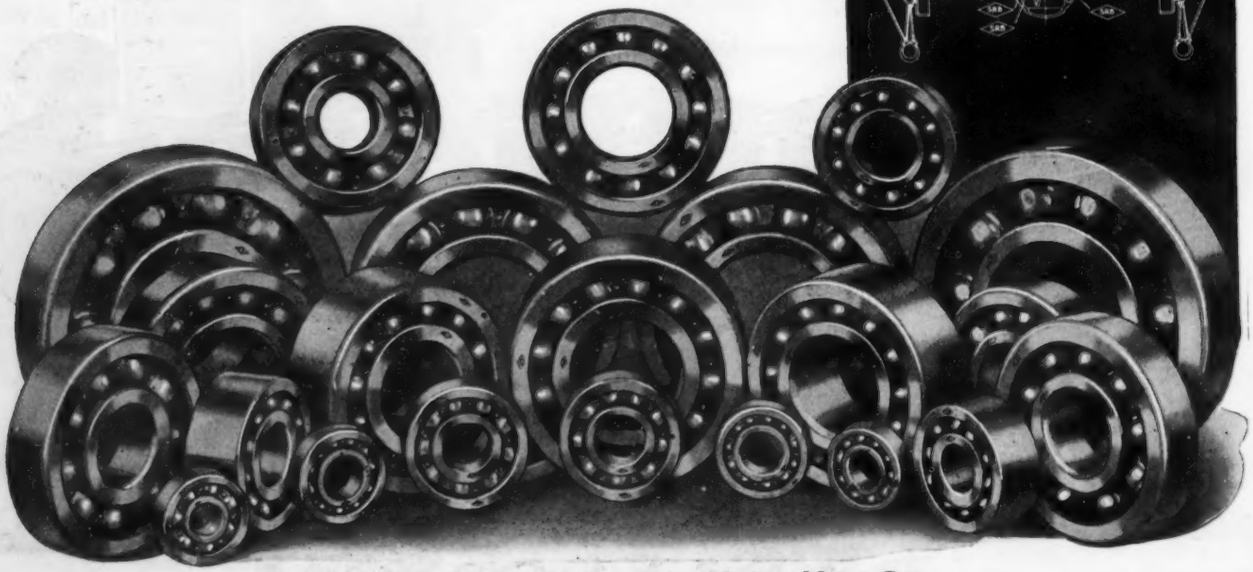
Philadelphia Standard Roller Bearing Co. | Plainville, Conn. | Norwich, Conn. | New Haven, Conn. | Pittsburgh Braeburn Steel Co.

Standard Sales and Service Distributors in Principal Cities

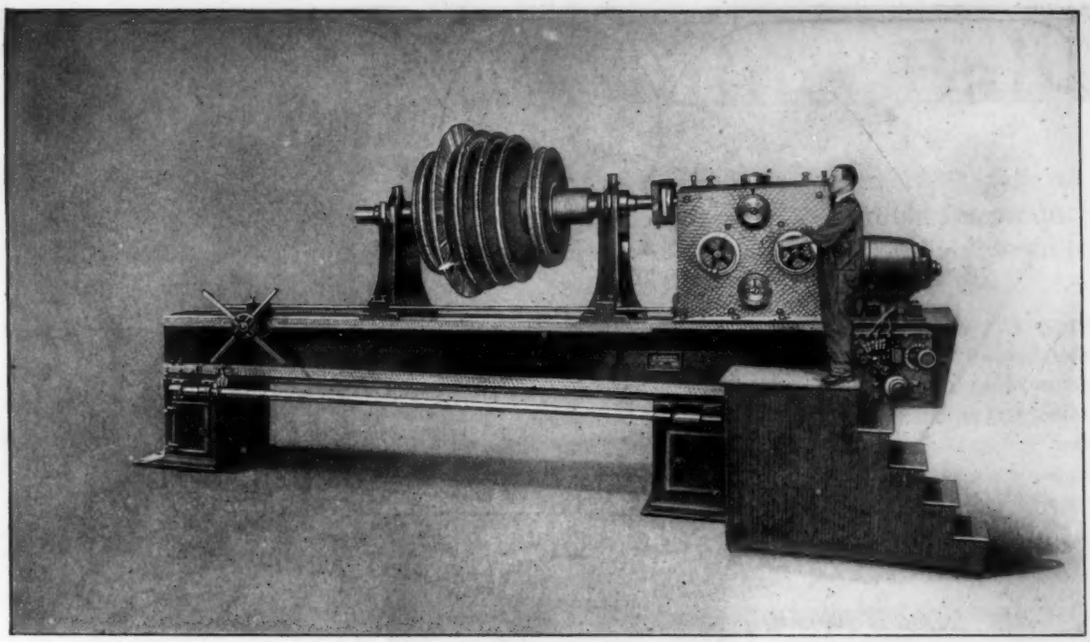
Executive Offices: 347 MADISON AVENUE, NEW YORK CITY

Controlled and Operated by

MARLIN-ROCKWELL CORPORATION



Typical S. R. B. Bearing Equipment for Modern Motor Car



A Practical Certain Method of Eliminating Vibration

TO obtain *static* balance on level ways is a comparatively simple matter but to find the *running* unbalance of such objects as turbine rotors, long crankshafts or motor generator armatures and correct it exactly has been one of the most bothersome problems to both mechanics and engineers.

With the Carwen Balancing Machine, however, and ordinary shop skill it is now possible to accurately locate where and measure exactly how much metal should be added to (or removed from) such an object to put it in precise running and static balance.

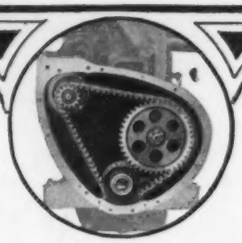
Carwens are being successfully used by the largest electrical companies for balancing armatures and turbine rotors; by manufacturers of airplane, automobile, truck and marine engines on their crankshafts and in every case the cost of purchasing and operating is practically negligible as compared with the vastly improved running qualities of the products.

Carwen machines are made in sizes for balancing objects weighing from 2 lbs. up to 40,000 lbs. Demonstration gladly given or descriptive literature sent upon request.

Manufacturers also of all classes of special machinery in conjunction with their screw machine products.

Lippincott-Carwen Corporation
Successor to A. H. & F. H. Lippincott and Carlson-Wenstrom Co.
Erie Ave. at Richmond St., Philadelphia, Pa.

CARWEN
Static-Dynamic Balancing Machine
(AKIMOFF AND LUNDGREN PATENTS)



THE NEW CLEVELAND "6"

A Series of Announcements

We take great pleasure in announcing that the new Cleveland "6" is equipped with the Morse front end drive.

Make your product better by joining the ranks of the famous car makers who use the Morse front end drive.

MORSE CHAIN COMPANY, Ithaca, New York

Detroit Office: 1003 Woodward Ave.

Baltimore, Md., 1402 Lexington Bldg. Philadelphia, Pa., 302 Harrison Bldg.

Genuine Babbitt

ISAAC BABBITT in 1839 gave to the industrial world a formula for producing a wonderfully useful alloy. It is known to the trade as Babbitt Metal.

Our modern, complete facilities enable us to produce Mogul Alloy Genuine Babbitt in exact accordance with this old original Isaac Babbitt formula—from copper, tin and antinomy. It is recognized as the best alloy for thin bearings, such as automobile motor bearings, which require a hard alloy, high in tensile strength. It is suitable for both die cast and hand-poured bearings.

Mogul Alloy Genuine Babbitt has met the exacting requirements of many users for twenty-five years.

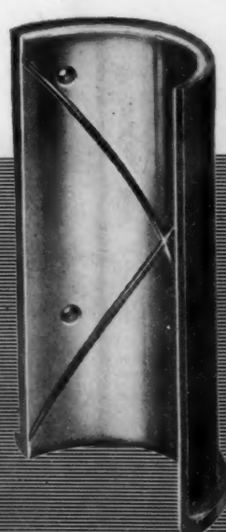
In addition to Mogul Genuine Babbitt the following brands have given 100% service and satisfaction to the trade for over twenty-five years:—Mogul No. 407 Nickel Babbitt; Mogul No. 408 Special Babbitt; Mogul Bearing Metal; Duro Metal. The jobbers listed below can supply you from stock.

We are equipped to make prompt deliveries on any grade of babbitt to meet special requirements.

Order Mogul Babbitt Alloys From These Jobbers

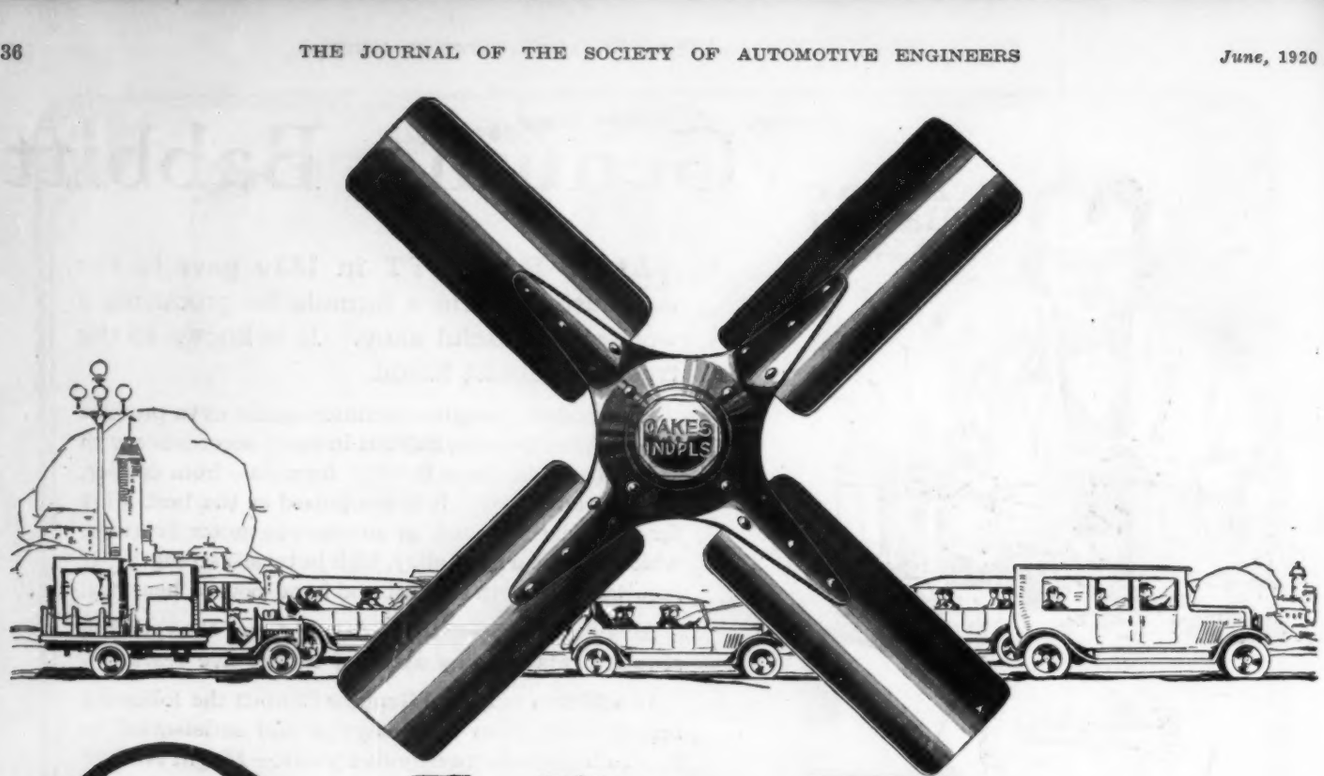
Armstrong-Wolfe-Zimmerman Co.	Pittsburgh, Pa.
Coghlin-Kirby Machinery & Supply Co.	Toledo, Ohio
Elderfield-Hartshorn Hardware Co.	Niagara Falls, N. Y.
J. D. Heckle & Co.	Memphis, Tenn.
W. W. Hite & Co.	Louisville, Ky.
F. Holtz Company	Evansville, Ind.
Edward Joy Co.	Syracuse, N. Y.
E. Keeler Company	Williamsport, Pa.
J. S. Krause-Hardware Co.	Bethlehem, Pa.
Philipsburg Hardware Co.	Philipsburg, Pa.
Reichenbach & Leiby	Allentown, Pa.
Smith Bros. Hardware Co.	Columbus, Ohio
Spaulding & Metcalf	Philadelphia, Pa.
Chas. A. Strelinger Co.	Detroit, Mich.
Chas. A. Strelinger Co., of Canada, Ltd.	Windsor, Ont.
The Wright Machine Co.	Owensboro, Ky.

MUZZY-LYON COMPANY, *Detroit, Mich.*



Mogul

Bearing Alloys *and* Finished Bearings



Efficient Cooling

Oakes Fans

THE proven ability of Oakes Fans to successfully cool motors under every service condition explains why they are now factory equipment on the big majority of quality cars, trucks and tractors manufactured in America

The OAKES COMPANY

Indianapolis, U.S.A.

PACIFIC COAST REPRESENTATIVE: A.H. COATES CO. 41 SPEAR ST. SAN FRANCISCO

OAKES

REMY undertakes no obligation which it cannot fulfill. No Remy salesman approaches a prospect without first having definite knowledge that the Remy system is adequately fitted in every way to meet that prospect's requirements. The Remy Company is as careful in its selection of customers as such customers must be in their selection of a supplying manufacturer.

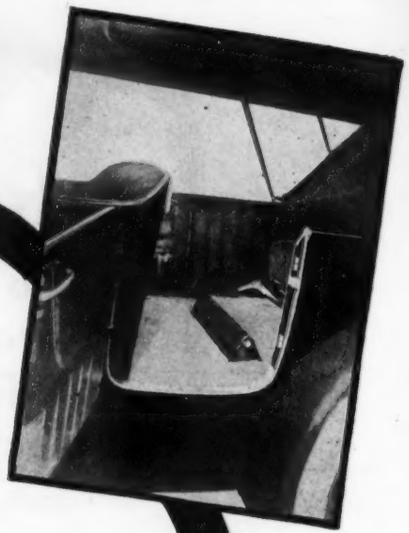
This preliminary investigation of a prospective customer's requirements before approaching him on behalf of the Remy system is an established part of the Remy honor-bound policy which permits of sales only where satisfactory service can be given.

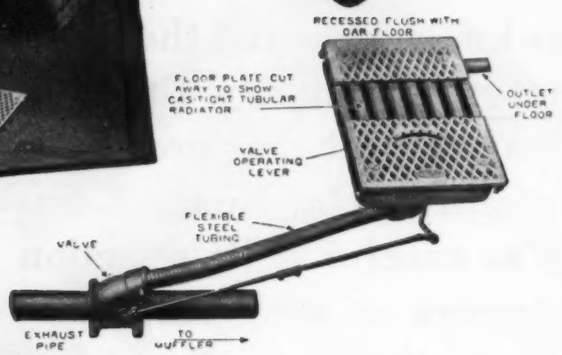
Remy Electric Company, Anderson, Ind.

REMY

STARTING LIGHTING IGNITION SYSTEMS

PERFECTION MOTOR CAR HEATERS





Experience Developed Perfection Motor Car Heaters

It required more than seven years of earnest toil to bring Perfection Motor Car Heaters to their present state of perfection.

We now have in full operation the most modernly equipped factory in the world for quantity and quality production of heater equipment.

Our engineering department will co-operate in figuring out the most efficient and economical heater installation for your passenger cars and truck cabs.

The Perfection Heater & Manufacturing Co.

6545 Carnegie Ave., Cleveland, Ohio

Manufactured and Distributed in Canada by Richards-Wilcox Canadian Co., Ltd. London, Ontario

Cars using Perfection Motor Car Heaters as standard equipment on one or more models:

Allen
Case
Cole Aero-Eight
Columbia
Crow-Elkhart
Davis
Dixie Flyer
Dorris
DuPont
Gardner
Grant
Haynes
Hudson
Holmes
Hupmobile
King
Kissel
Liberty
Maibohm
Marmon
Mercer
Mitchell
Moon
National
Northway Motors Corp. (truck cabs)
Oakland
Oldsmobile
Paige
Premier (all models)
ReVere
Roamer
R. & V.
Scripps-Booth
Standard Eight
Stephens Salient Six
Stutz
Templar
Velie
Westcott
Willys-Knight
Yellow Taxicabs of Chicago

Timken Leadership

R T B CO

Among Engineers

Training and experience both lead the engineer to pin his faith to facts.

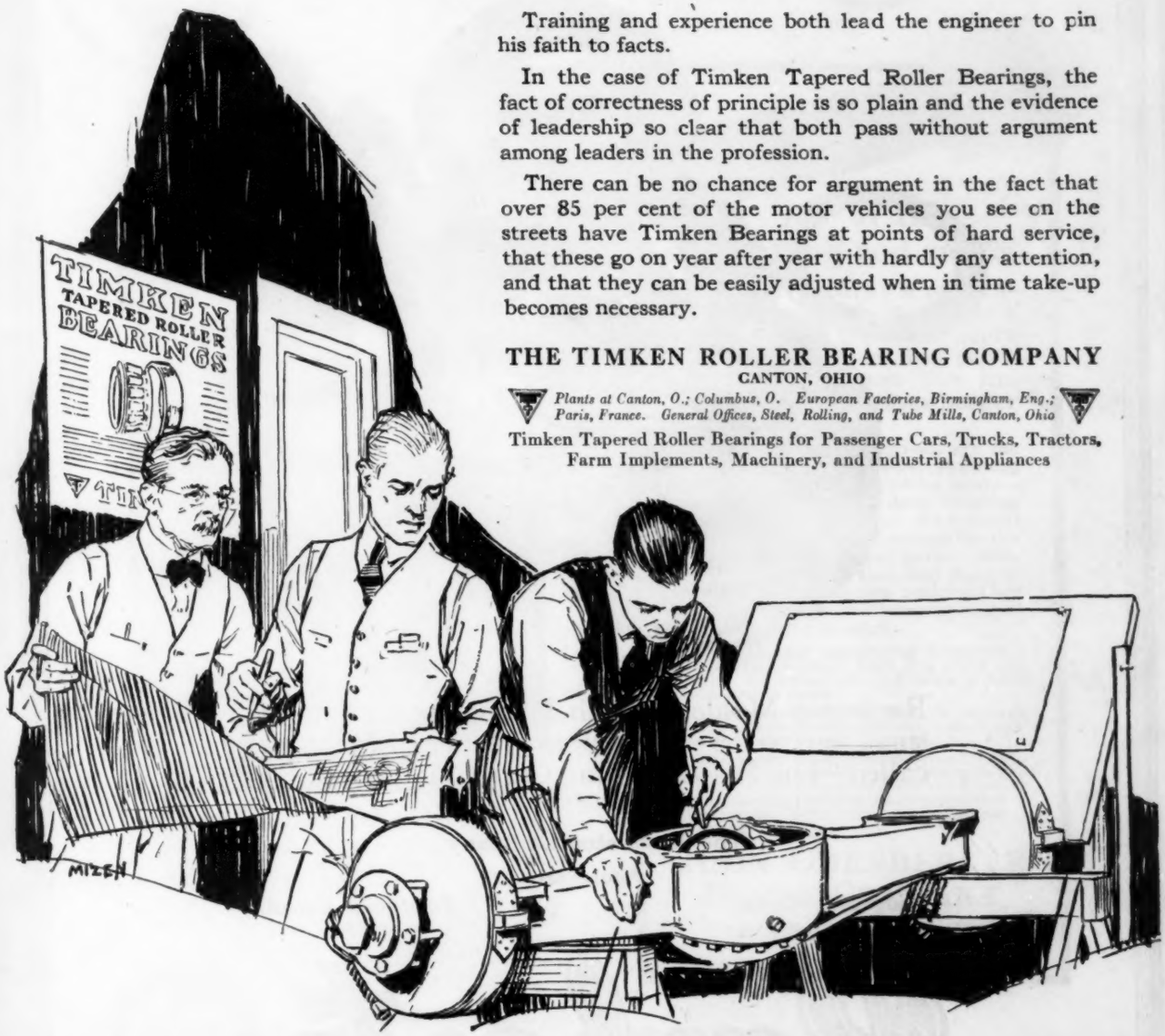
In the case of Timken Tapered Roller Bearings, the fact of correctness of principle is so plain and the evidence of leadership so clear that both pass without argument among leaders in the profession.

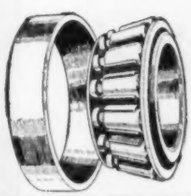
There can be no chance for argument in the fact that over 85 per cent of the motor vehicles you see on the streets have Timken Bearings at points of hard service, that these go on year after year with hardly any attention, and that they can be easily adjusted when in time take-up becomes necessary.

THE TIMKEN ROLLER BEARING COMPANY
CANTON, OHIO

Plants at Canton, O.; Columbus, O. European Factories, Birmingham, Eng.; Paris, France. General Offices, Steel, Rolling, and Tube Mills, Canton, Ohio

Timken Tapered Roller Bearings for Passenger Cars, Trucks, Tractors, Farm Implements, Machinery, and Industrial Appliances





STANDARD PRACTICE
The use of Timken Tapered Roller Bearings at points of hard service in the great majority of motor-vehicles is proof of leadership established on the tapered principle of design, quality of manufacture, performance on the road, and service to the automotive industry

TIMKEN BEARINGS

MARMON

Raybestos Molded Clutch Facings contribute no small part to the smooth performance of Marmon, called "The Easiest Riding Car in the World."

The Raybestos Company

Factories

Bridgeport Conn. **Peterboro Canada**

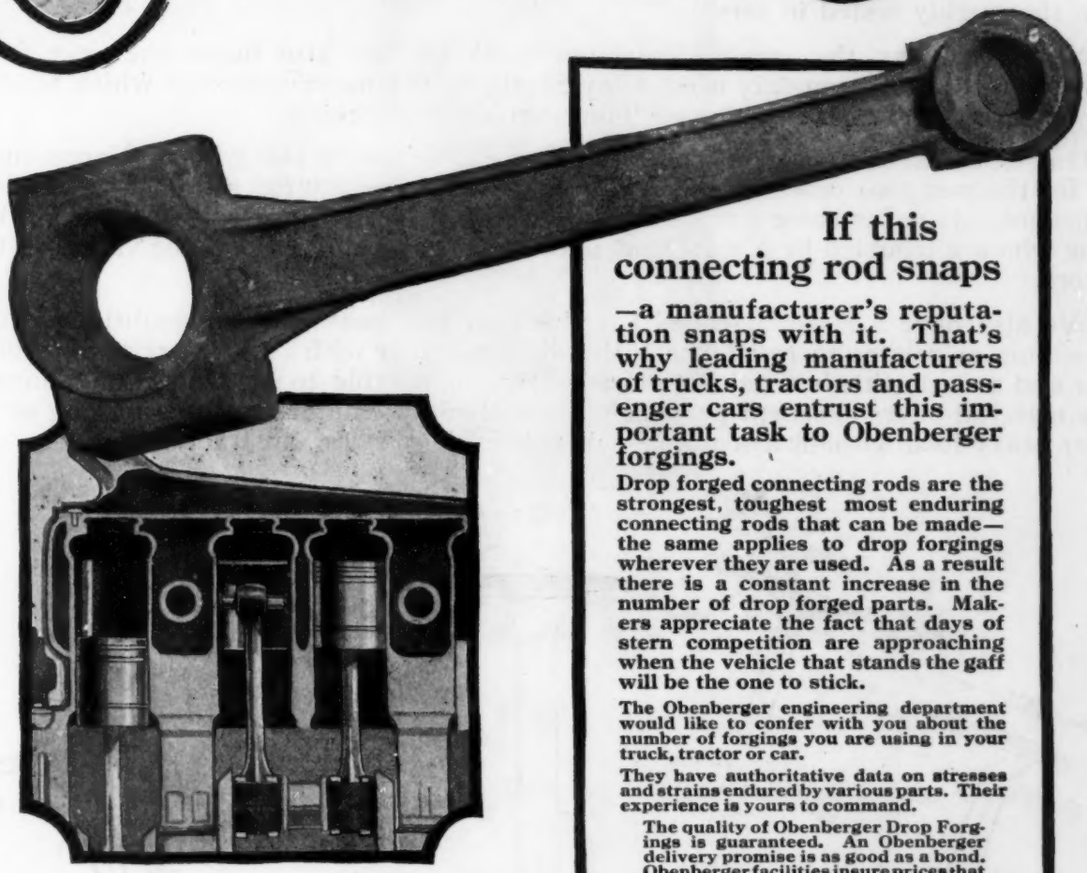
Raybestos

Molded Clutch Facing

Patented — Guaranteed

Obenberger

Look for the name on high grade forgings



If this connecting rod snaps

—a manufacturer's reputation snaps with it. That's why leading manufacturers of trucks, tractors and passenger cars entrust this important task to Obenberger forgings.

Drop forged connecting rods are the strongest, toughest most enduring connecting rods that can be made—the same applies to drop forgings wherever they are used. As a result there is a constant increase in the number of drop forged parts. Makers appreciate the fact that days of stern competition are approaching when the vehicle that stands the gaff will be the one to stick.

The Obenberger engineering department would like to confer with you about the number of forgings you are using in your truck, tractor or car.

They have authoritative data on stresses and strains endured by various parts. Their experience is yours to command.

The quality of Obenberger Drop Forgings is guaranteed. An Obenberger delivery promise is as good as a bond. Obenberger facilities insure prices that are right. Send your blue prints for quotations.

JOHN OBENBERGER FORGE COMPANY

West Allis, Milwaukee, Wis.

JOHN OBENBERGER FORGE CO. Obenberger Forgings MILWAUKEE WIS. PLANT WEST ALLIS

THE MARK THAT STANDS FOR OBENBERGER SERVICE

Forgings

RICH TOOL COMPANY

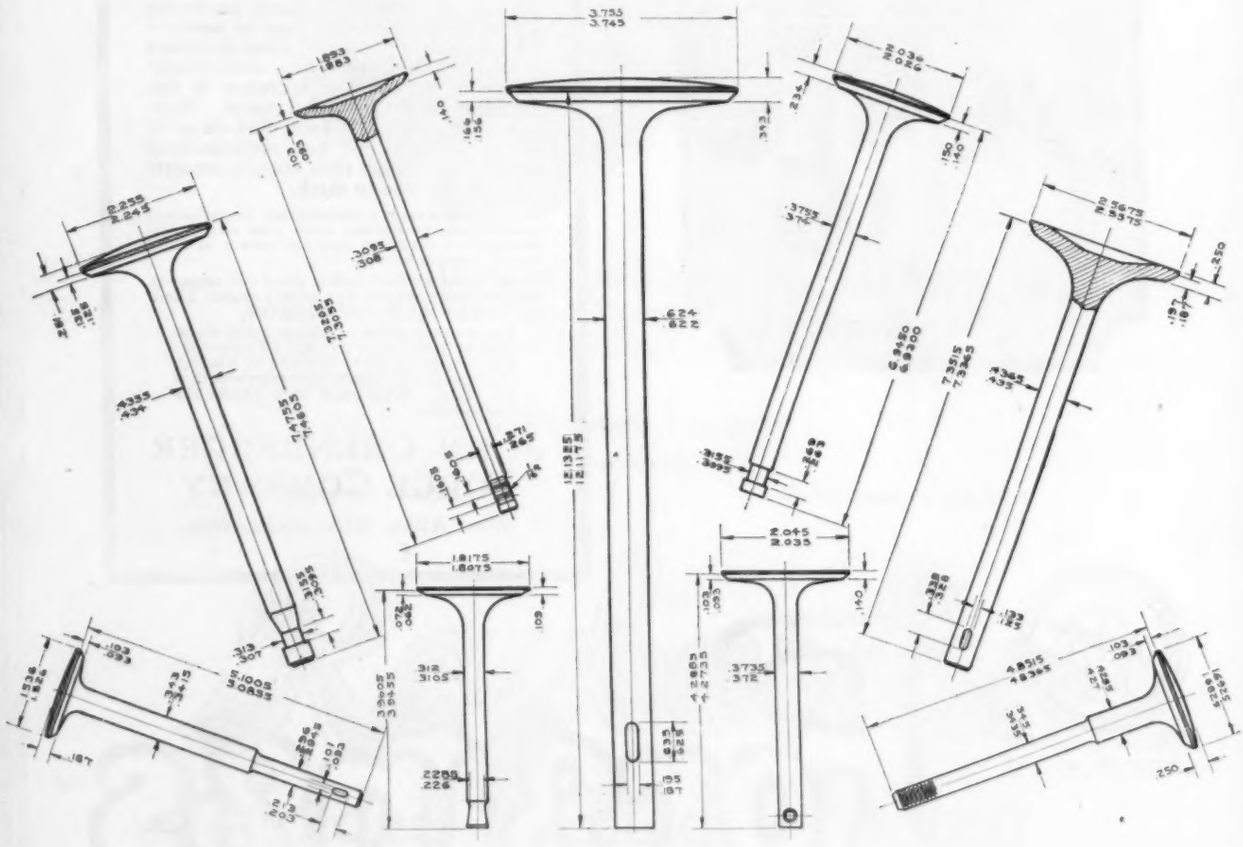
Railway Exchange Bldg., Chicago, Ill. **Kresge Building, Detroit, Mich.**

The cuts below represent valves used in some of the best known present day Aeroplane, Motor Boat and Racing Automobile Engines. They are all products of this Company and most of them have been produced in large quantities and have, therefore, been thoroughly tested in service.

Needless to say, they are all Tungsten Steel, but we also make one-piece forged valves of all other commonly used Alloy Steels, in the manufacture of which we exercise the same care as is used in our Tungsten Valve materials.

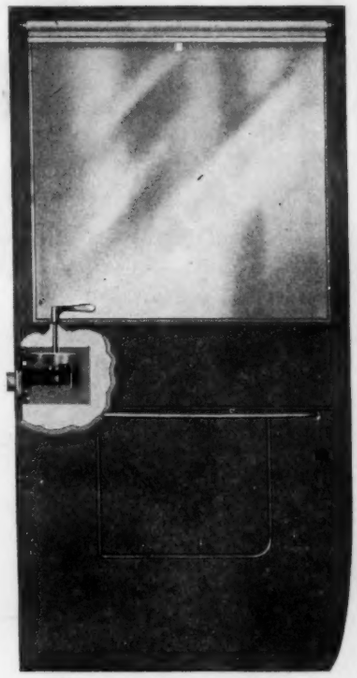
One of the newer types of valves which we have been making in very large quantities for the past two years is our Hi-Chromium Valve, which has some very remarkable properties. It is for some purposes an excellent valve and we solicit inquiries from those who are troubled by a persistent burning away of the seats of the valves in their motors.

We also have a material called Cobalt-Crom that possesses the qualities of High-Chromium as relates to resistance to burning, together with a resistance to abrasion or wear and a strength when red hot more nearly comparable to that of High-Tungsten. This material offers excellent promise of good results in engines running for long periods under heavy load without attention, such as marine motors and tractor motors.



Our Engineering Department is at your service on all questions concerning suitability of material and design.

E&M



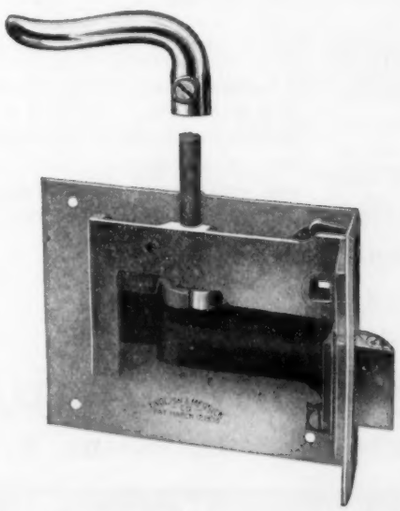
A single, easy motion — a quarter-turn of the handle — both unlocks and opens the door.

ENGLISH & MERSICK

Rotary Lever Lock

E&M

Visible on Every Lock



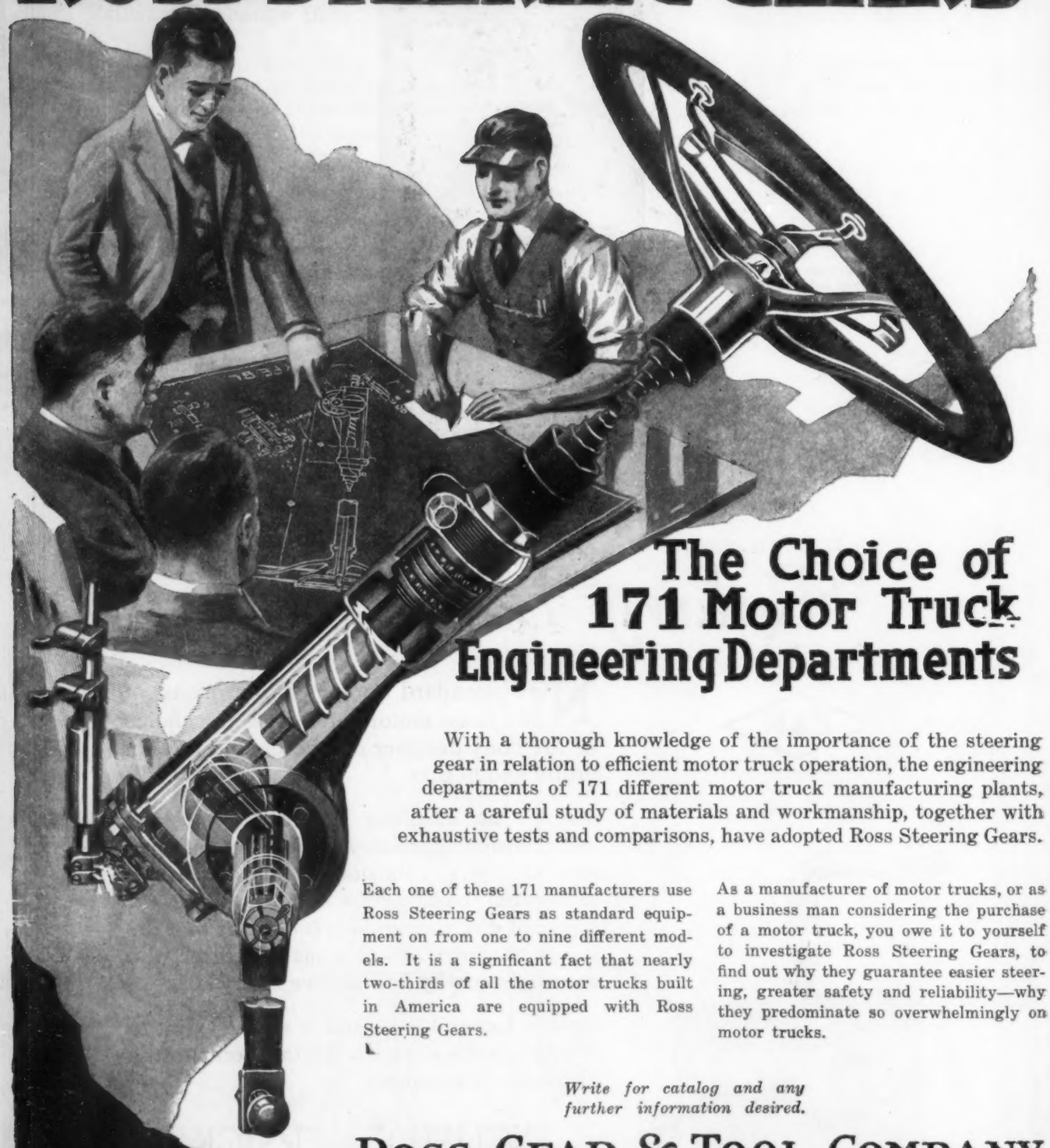
NOW standard equipment on many of the finest motor cars. It is the choice of the body designer on the double basis of utility and beauty.

There's no unsightly slot in the finishing rail or inside upholstery of the door equipped with this lock. Its simple, easy action and substantial construction appeal to the car buyer of discrimination. It denotes that the car is the product of a manufacturer who considers quality and service first.

Rotary Lever Locks add a selling point to the car's value—and a talking point to the distributor's argument.

The ENGLISH & MERSICK CO.
New Haven, Conn.
Since 1860 makers of fine body hardware
Locks Hinges Handles

ROSS STEERING GEARS



The Choice of 171 Motor Truck Engineering Departments

With a thorough knowledge of the importance of the steering gear in relation to efficient motor truck operation, the engineering departments of 171 different motor truck manufacturing plants, after a careful study of materials and workmanship, together with exhaustive tests and comparisons, have adopted Ross Steering Gears.

Each one of these 171 manufacturers use Ross Steering Gears as standard equipment on from one to nine different models. It is a significant fact that nearly two-thirds of all the motor trucks built in America are equipped with Ross Steering Gears.

As a manufacturer of motor trucks, or as a business man considering the purchase of a motor truck, you owe it to yourself to investigate Ross Steering Gears, to find out why they guarantee easier steering, greater safety and reliability—why they predominate so overwhelmingly on motor trucks.

Write for catalog and any further information desired.

ROSS GEAR & TOOL COMPANY

Eighth and Heath Streets, Lafayette, Indiana, U. S. A.

The Steering Gears that Predominate on Motor Trucks

WORM GEAR DRIVES

of our

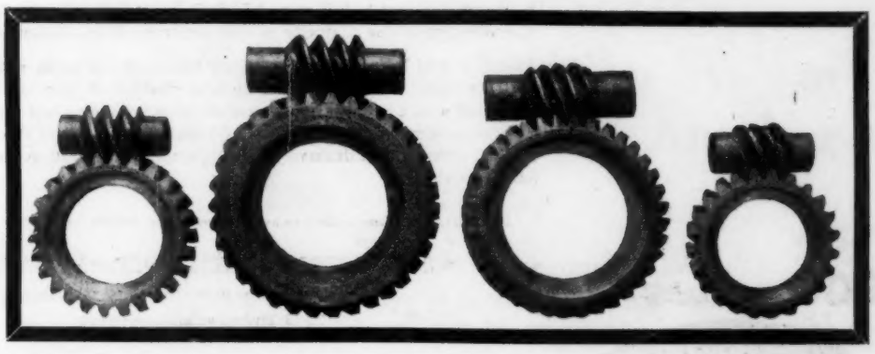
HY-TEN-SL BRONZE

have the following advantages:

100% better wearing qualities.

Lower cost.

7% lighter than other gear Bronzes.



Resistance to Wear:—

We call attention to wearing test as tabulated opposite. Under the most exacting long service tests on automobile trucks with hardened steel worms, it has shown no appreciable wear. Its close grained, homogeneous structure, its uniform hardness (about 130 degrees Brinnell) and its exceedingly tough structure, insure the best wearing qualities.

WEAR TESTS ON GEAR BRONZES

Holz Universal Wear Testing Machine

Name of Bronze	Hy-Ten-Sl Gear Bronze	English Gear Bronze	Another Gear Bronze
Composition		Sn 11 Cu 88.50 Zn .50	Sn 11 Cu 84.50 Zn 4.50
Tensile strength	90,000	32,000	31,000
Duration of test	2 hours	2 hours	2 hours
Rev. per min.	184.2	185.8	185.8
Load carried (kilograms)	200	200	200
Weight of test piece before test (grams)	82.2290	89.1551	88.6671
Weight of test piece after test (grams)	82.2255	89.1421	88.6468
Loss during test (grams)	.0035	.0130	.0203

AMERICAN MANGANESE BRONZE COMPANY

HOLMESBURG PHILADELPHIA, U.S.A.

Continuous performance is what counts

ASK any garage repair man and he will tell you that worn bearings have helped build his overhaul business. Ask any automotive engineer and he will say that machine life—the ability to deliver a full quota of horsepower hours—depends vitally on bearing performance.

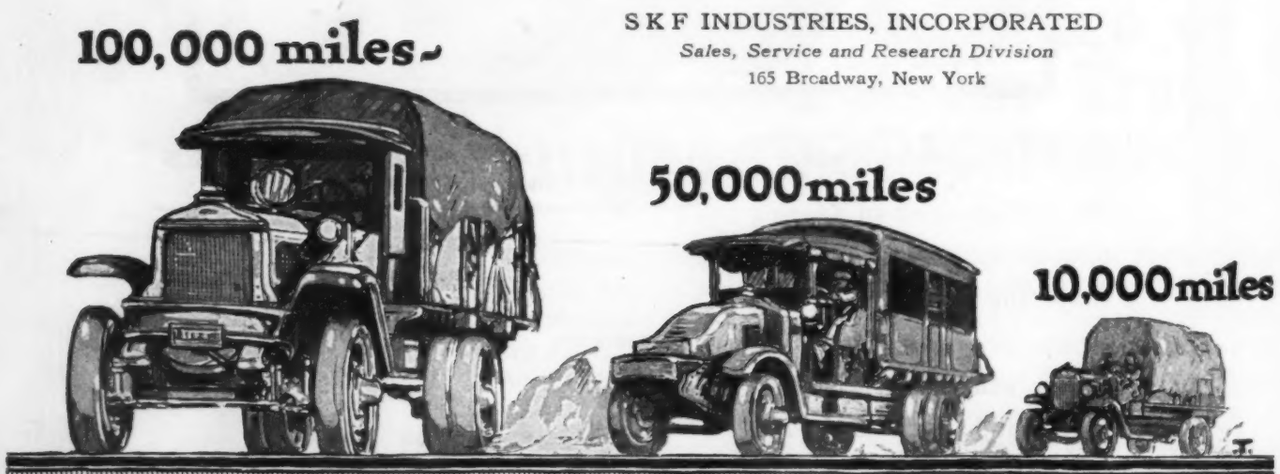
For just as soon as the bearings in your truck start to wear, lost motion causes destructive vibration that quickly hammers the internal parts into a state of inefficiency. The result is lessened economy, higher maintenance cost—early destruction, particularly of transmission and drive.

The fact that practically all the leading truck manufacturers place ball bearings at the points of greatest possible wear is convincing evidence that this form of bearing wears longest. Under proper conditions of selection and use, ball bearings should not wear at all—normal car life considered. And it is significant that S K F and HESS-BRIGHT ball bearings are built into the vehicles of the majority of the better truck manufacturers.

In S K F and HESS-BRIGHT ball bearings we have not only developed the anti-friction bearing to its highest perfection, but we have further established a scientific research and engineering organization that is shouldering the automotive manufacturers' bearing problems. We are endeavoring to serve American industry through this contribution to the building of better trucks.

Manufacturers are invited to avail themselves of this freely offered co-operation

S K F INDUSTRIES, INCORPORATED
Sales, Service and Research Division
165 Broadway, New York



SKF INDUSTRIES

Hess-Bright Ball Bearings
S K F Ball Bearings
Atlas Steel Balls
Gronkvist Chucks
Transmission Hangers

596

The S K F Research Laboratory where friction problems are solved

PHILBRIN IGNITION

An Actual Test of An Ignition System Is More Convincing Than Another Man's Say-So

We Can Show You the Signed Testimony of Engineers, Owners and Race Drivers Regarding the Amazing Results Produced by Philbrin—

But here is a better way—

When we tell you the whole truth about Philbrin's astonishing achievements, your first impulse is to say: "Impossible!"

So the best part of it seldom gets into print. There are some figures on gas saving and power increase, for example, that would stir up considerable amazement. They *do* seem incredible.

But your own eyes don't exaggerate.

And for that reason we say: "Don't judge Philbrin by what we claim for it, or what Ira Vail says about it, or by anybody else's comments. Don't go by its design, or its construction, or its theory. Just *test* it, result for result, alongside the system that is now standard equipment on your cars. Compare starting, pick-up, acceleration, power, speed and gas mileage—"

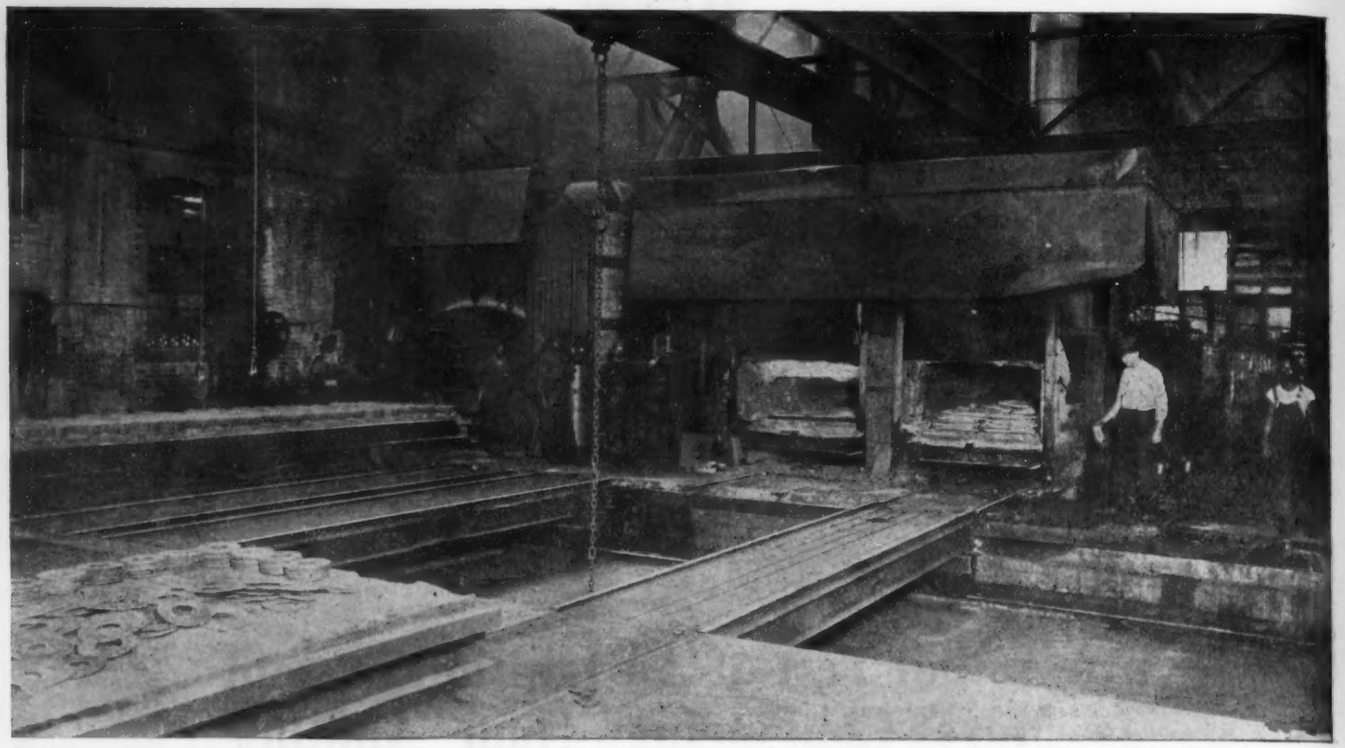
And it will become evident what we have achieved in the development of the Philbrin contact maker and condenser—the source of that crashing spark that makes combustion complete and instantaneous.

With the secondary or High Frequency system—a feature of Philbrin Duplex Ignition—a turn of the switch sends a torrentuous downpour of sparks into each cylinder in firing orders, insuring quick starting, exploding the poorest mixtures, overcoming bad oil conditions, preventing plug fouling: an emergency system of inestimable value.

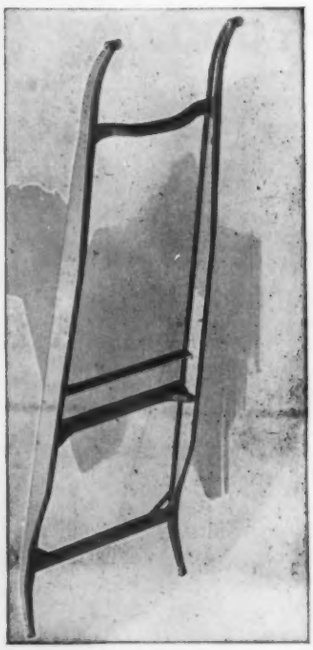
Make this test. We will gladly co-operate with you in every way.

PHILBRIN
TRADE MARK

PHILIPS-BRINTON CO. **KENNETT SQUARE, PA.**



Annealing Ovens



The "Insurance" Behind

5. Annealing and Pickling

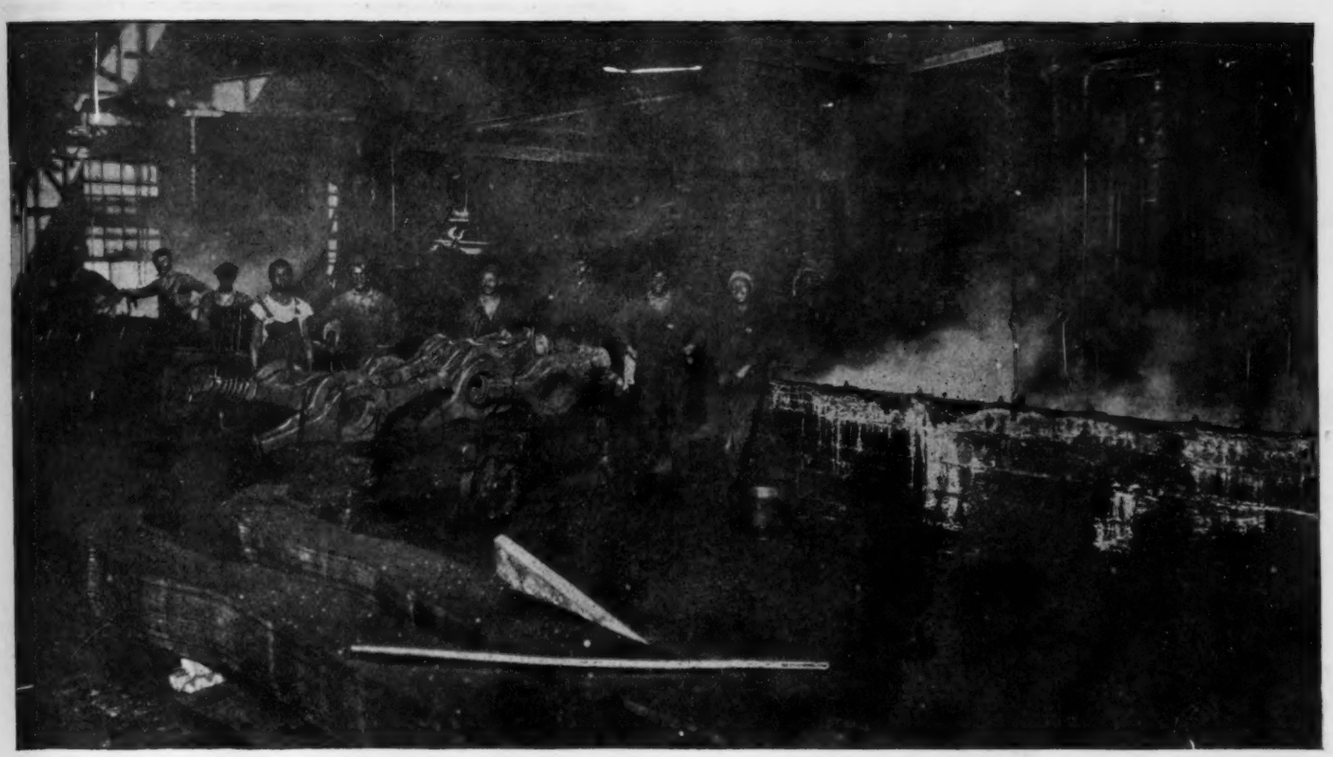
The perfection of Hydraulic Frames is further advanced in the annealing furnaces, relieving the internal stresses and preparing the frame for forming and straightening.

In the pickling vats, all scale and exterior impurities are removed. Linked up with these processes is the rigid Hydraulic inspection, insuring Hydraulic customers of a high standard of quality and materials.

The Source of Supply an Important Factor

An important factor in delivery is an assured source of supply. The Canton Sheet Steel Company of the Hydraulic Steel Company gives this assurance.

HYDRAULIC



Pickling Vats

Hydraulic Frames

Hydraulic standards in the making and delivery of the steel are the foundation upon which the Hydraulic Frame is built.

Manufacturers of

Pressed Steel Frames for Passenger Cars, Trucks and Tractors; Axle Housings; Brake Drums; Torque Arms; Running Boards; Step Hangers; Hub Flanges; Discs; Dust Shields; Steel Barrels; Aeroplane and Miscellaneous Stampings.

THE HYDRAULIC PRESSED STEEL COMPANY
of THE HYDRAULIC STEEL COMPANY
CLEVELAND, OHIO

Branch Sales Offices:

New York	Chicago	Detroit
Singer Building	Fisher Building	Book Building

"MORE Than a Place to Work"

"In the Hydraulic plan of organization, each individual is dependent upon the other for results and each shares with the other in the reward of accomplishment. We are, therefore, interested in helping the other fellow get the knowledge which will make him useful, in the thinking which will give him vision and inspiration, and in the actual doing of his part."

PRESSED STEEL COMPANY

The Right Drive in the Right Place

There's a most efficient way to transmit power, positively and dependably from shaft to shaft on the machines you design and build.

It may be by means of a belt, or gears,—or chains.

But if your problem is to transmit that power, positively, without such slippage as results from stretched belts—

Or if the centers are too short for their use—

If the drive of necessity must be exposed to the action of moisture, dust or chemicals—

If the power must be transmitted with a minimum amount of friction loss—

Then—the logical answer is Baldwin Chain and Sprockets.

BALDWIN CHAIN & MANUFACTURING COMPANY
WORCESTER, MASS.

H. V. GREENWOOD, General Western Sales Agent. PEOPLES GAS BUILDING, CHICAGO, ILLINOIS.

Baldwin Agents

Boston, Mass.
Walter H. Williams
175 Massachusetts Ave.

Chicago, Ill.
W. D. Foreman
22 E. Eighteenth St.

Cincinnati, Ohio
Wirthlin-Mann Co.
318-320 West Third St.

Cleveland, Ohio
Chain & Sprocket Service Co.
1794 East 55th St.

Detroit, Mich.
Baldwin Service Co.
1905 Woodward Avenue

Kansas City, Mo.
Motor & Machinists' Supply Co.
1617 Grand Ave.
Faeth Iron Works

Los Angeles, Cal.
Colyear Motor Sales Co.
1222-1226 So. Hill St.

Minneapolis, Minn.
Baldwin Service Co.
39 South 11th St.

New Orleans, La.
M. H. Rykoski
706-708 Julia St.

New York City
C. D. Schmidt Co.
276 Canal St.

Philadelphia, Pa.
N. A. Petry Co., Inc.
1307 Race St.

Portland, Oregon
H. W. Sharp Co.
72 First St.

Providence, R. I.
Lanphear Motor Car Co.
17 Snow St.

San Francsico, Cal.
The Adam-Hill Co.
96 Ninth St.

Seattle, Wash.
Wade & Co.
313 East Pine St.

St. Paul, Minn.
C. J. Smith & Co.

St. Louis, Mo.
American Automobile and Supply Co.
3200 Locust St.

Montreal, Toronto, Winnipeg, Can.
Lyman Tube & Supply Co., Limited

GENUINE BALDWIN CHAINS

Positions & Men Available

The following announcements are published for the benefit of members of the Society and the convenience of companies in need of men. No charge whatever is made for this service. In the case of items prefixed by an asterisk further information is withheld at the request of the company or individual making the insertion, but written communications bearing the number of such items will be forwarded by the S. A. E. Office. In other cases further information will be supplied by the Office of the Society. Applications for positions from non-members must be endorsed by a member of the Society.

0830 YOUNG TECHNICAL ENGINEER with a practical knowledge of production, record keeping, follow-up and detail work and industrial management, also drafting. Now located in New York.

0831 ENGINEER now with the truck division of a large motor car manufacturer desires a position in sales or sales promotion work with reputable manufacturer of trucks or truck units. Has had ten years' experience in design and production of commercial vehicles.

0832 SALESMAN with wide acquaintance among buyers in the automobile, truck and tractor trade is desirous of acting as a factory representative for Michigan and Ohio. Can produce results and will furnish references upon request.

0833 SALES ENGINEER with an office in New York City wishes to negotiate with responsible manufacturers for their representation in either sales or service in the East or metropolitan district. At present associated with Pennsylvania parts manufacturing corporation. Ten years' experience in sales, service and engineering. Can finance own sales organization.

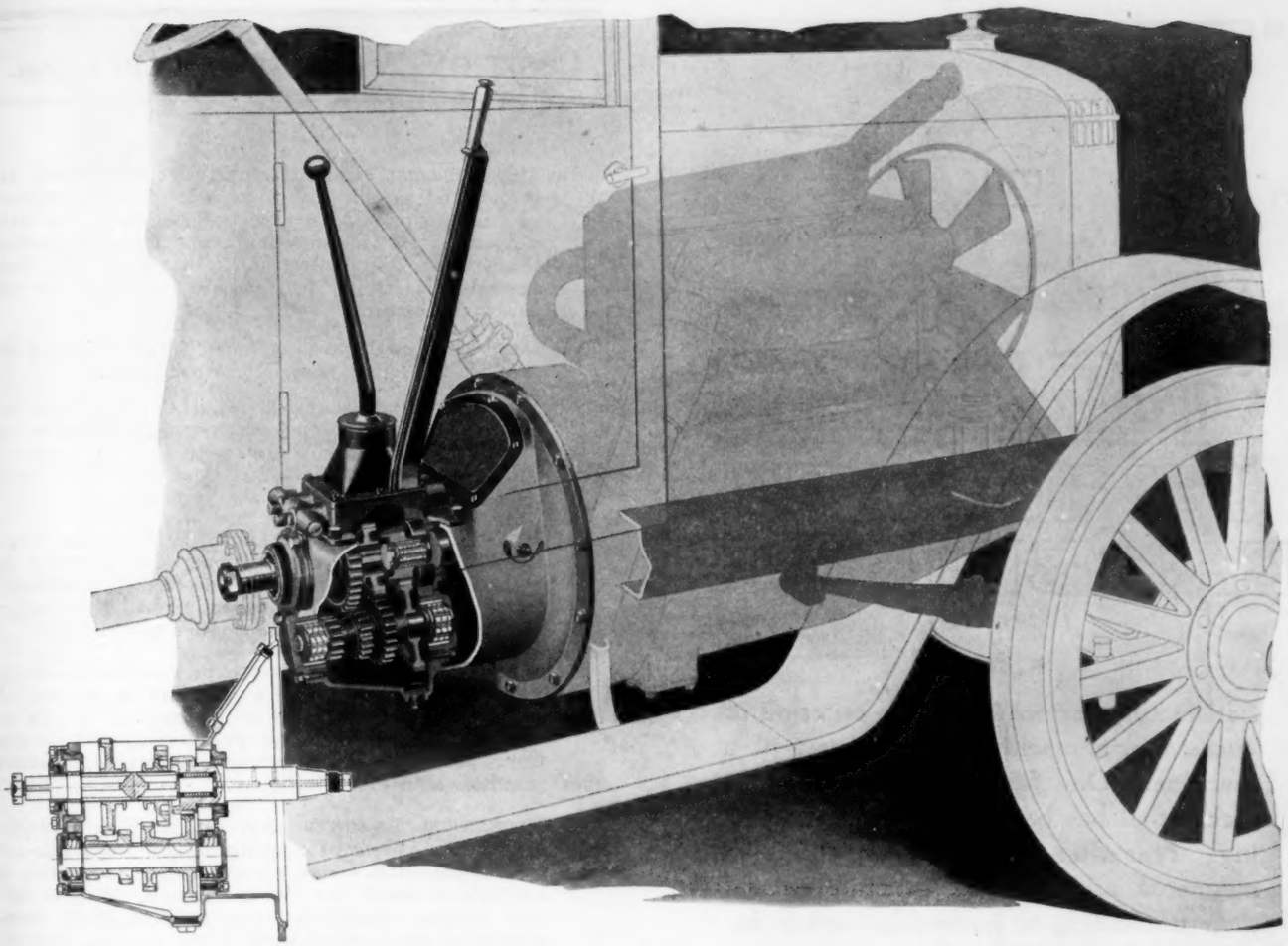
0834 MANUFACTURING EXECUTIVE Sixteen years as foreman, general foreman, assistant superintendent and superintendent. Thoroughly competent to handle production engineering on large or small parts in quantity production.

0835 ENERGETIC YOUNG MAN with sales ability and wide experience in engineering and production of motor cars and parts desires to become Eastern representative of automotive parts concern.

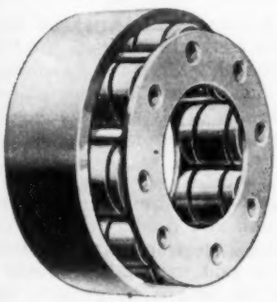
0838 GENERAL SALES MANAGER for accessory manufacturer. Graduate engineer, with two years' shop experience, nine years' publicity and sales of which three years were with well-known parts manufacturer. Capable along engineering lines as well as selling. Clean record, hard worker, excellent references, available immediately.

0839 GRADUATE MECHANICAL ENGINEER employed at present desires to locate in the East. Has a thorough knowledge of production and machine-shop methods. Special training in material inspection and tests. Competent to take charge of steel treatment room and produce results.

(*Continued on page* 52)



A Transmission Simplified by Hyatt Roller Bearings



And in Operation

Hyatt Roller Bearings relieve the transmission of all the road shocks and strains—insuring perfect alignment of gears and shafts—thereby minimizing wear and tear.

In addition, they are self-oiling, never need adjustment and survive throughout the working life of the truck. To have them in your transmission is your assurance of dependable truck service.

The compact transmission of this truck has Hyatt Roller Bearings on the countershaft ends and on the "spigot" end of the mainshaft, where it pilots into the clutch gear.

The "spigot" bearing consists of a cage of small rollers. Elimination of races at this point permits holding shaft parts to a minimum diameter. Bearings without inner races are used on the countershaft, thereby doing away with extra parts. End thrust is taken through generous contact surface against plain oil channeled end caps.

This design illustrates the sound manner in which Hyatt Roller Bearings, through their adaptability, make possible a simple construction and enable the manufacturer to build a more satisfactory transmission without adding to the cost of the unit.

Hyatt Roller Bearing Company, ***Motor Bearings Division,*** **Detroit, Michigan**

HYATT QUIET BEARINGS

"NORMA"
PRECISION
BALL BEARINGS
(PATENTED)

Satisfactory service is the one criterion of success in a machine or in a part of a machine. One failure will wipe out a record that has been months in the making. Year after year "NORMA" equipped magnetos and lighting generators hold their unchallenged leadership—solely by virtue of their consistently superior service maintained under the most exacting conditions known in the automotive world.

See that your electrical apparatus is "NORMA" equipped.

THE NORMA COMPANY OF AMERICA
Anable Avenue
Long Island City
New York

Ball, Roller, Thrust and Combination Bearings

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Continued)

0840 METALLURGICAL ENGINEER whose qualifications are strong and specific for responsible executive position as manager or metallurgical engineer desires to make a change. He is equipped for a responsible position through excellent experience and has thoroughly demonstrated his ability to supervise operations for efficiency and economy.

0841 DRAFTSMAN experienced on motor trucks desires a position in California, Oregon or Washington.

0842 EFFICIENCY ENGINEER with technical education and experience as supervisor of efficiency department of one of the largest automobile wheel plants will accept a position requiring either all or part time. Has developed a system adaptable to any product.

0843 MECHANICAL DRAFTSMAN Age 26. Over two years' machine-shop experience and one year assembly inspection on airplane engines and one year draftsman. At present assistant to manager in small manufacturing plant. Available on one month's notice.

0844 TRACTOR ENGINEER, ten years' experience on tractor design and development and eight years on gas engine. Competent to take charge of engineering for an established company or design and development for new firm. Shop trained and technically educated, possesses executive ability and initiative.

0845 MECHANICAL ENGINEER Age 28, married, technical graduate. Experiened in spring design, production and plant engineering, design, construction and operation of complete producer gas plants and application to furnace heating operations. Desires production, maintenance or development work in the vicinity, Detroit.

0846 ENGINEER Ten years' experience on two and four-wheel drive trucks, passenger cars and tools for these vehicles. Technical graduate. Location desired Middle West, preferably Michigan.

0847 SUPERINTENDENT OF AUTOMOBILE AND GAS ENGINE FACTORY desires to make connection with a progressive company where ability and success in handling production problems will insure advancement. Eighteen years' experience in various departments. Capable of handling any department of a factory. Age 33. Married.

0848 AERONAUTICAL ENGINEER, with nine years' experience in the design, construction and production of aircraft, thoroughly familiar with shop practice, energetic, possessing executive ability and originality, would consider an executive position with a progressive organization. At present chief engineer for an Eastern aircraft company. West preferred but not essential.

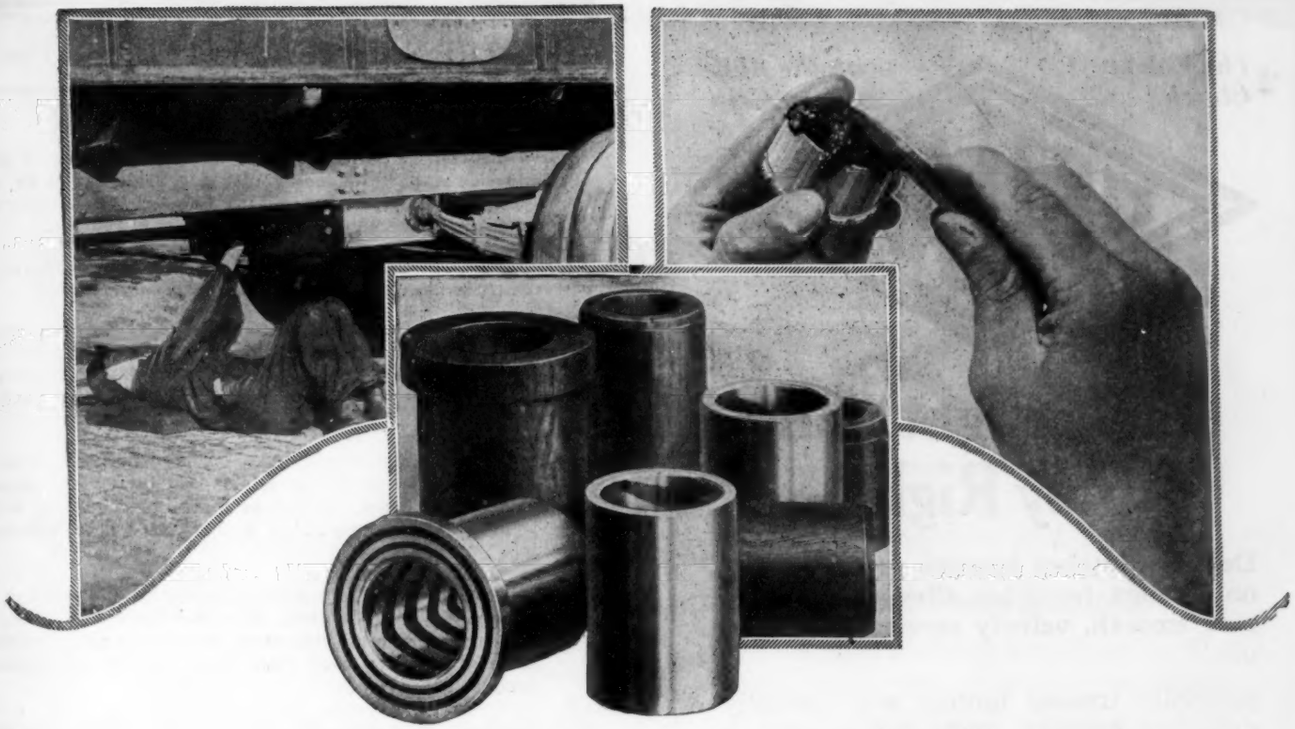
0849 ENGINEER Designer, capable of designing and building engines, automobiles, trucks, etc.

0851 ENGINEER with fourteen years' experience in the design, construction and sale of transmissions and axles desires to make a connection as sales engineer along these lines. Is familiar with the mounting and installation of anti-friction bearings.

0852 YOUNG EXECUTIVE ENGINEER, having several years of practical shop work and general experience in business and automotive parts manufacturing, would like

(*Continued on page* 54)

*See announcement at the head of the "Positions and Men Available" column, page 50.



Why Cars and Trucks Are Being Equipped with Oil-Less Bushings

—Because they banish the risk of premature wear and breakdown resulting from neglected lubrication.

—Because they eliminate the necessity of lying under the chassis to remove, refill and replace the 25 or 30 grease cups that supply lubricant to the chassis bearings.

*—Because Bound Brook and Nigrum Oil-less Bushings, by virtue of their construction, are able to give more efficient service, despite neglect, than any ordinary type of Bushing.**

Car and truck makers know that every plain bushing at inaccessible bearing points simply multiplies the chances of trouble. Owners and drivers are human enough to give but scant attention to details that require hours of irksome labor.

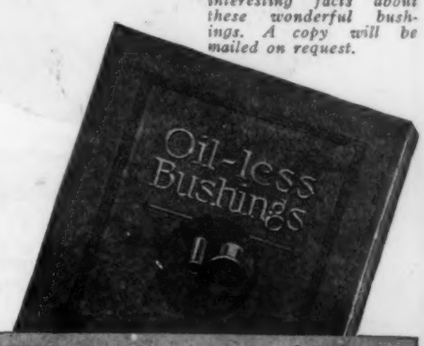
And no chassis assembly can stand up—serve out its full period of usefulness—with friction and corrosion gnawing at its vitals.

So you find "Bound Brook" (*Graphite and Bronze*) and "Nigrum" (*Impregnated Wood*) Oil-less Bushings growing rapidly in favor and use among car and truck manufacturers.

For they realize that Oil-less Bushings supply an imperative need—full and permanent protection against the costly consequences of neglect.

All genuine Graphited Oil-less Bushings have always been made at Bound Brook, U. S. A.

*The Bound Brook Catalog contains many interesting facts about these wonderful bushings. A copy will be mailed on request.



Bound Brook Oil-Less Bearing Co.

Specialists in the manufacture of Oil-less Bushings for more than a third of a century.

Bound Brook **New Jersey**

Detroit Office: 1723 Ford Building

The Velvet Clutch *With the Bull-dog Grip*

DETLAFF

Built Right and Stay Right

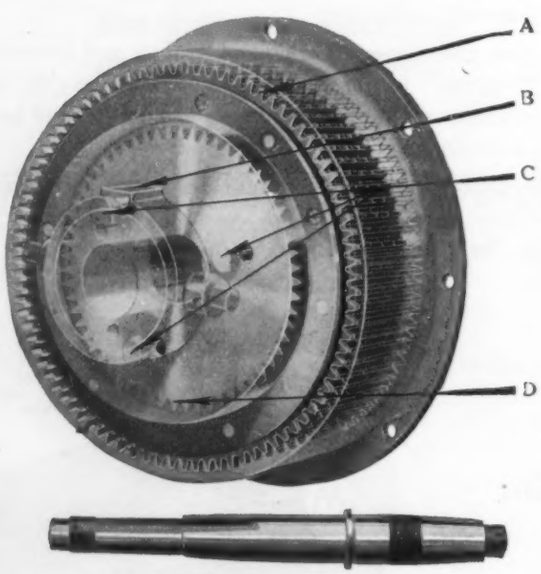
Detlaff Clutches operate perfectly, not only when new, but they continue to give smooth, velvety service after long use.

Specially treated linings and specially designed springs make adjustment a matter of years of use, not months, and the construction throughout is of a quality that gives freedom from the necessity of frequent care.

We will gladly send manufacturers all data on Detlaff Clutches.

A. J. Detlaff Company

126 Lafayette Ave., East Detroit, Mich.



A, D—Gear-tooth drive on all discs.
B—Lubrication from any convenient point.
C—Long, easy springs compensate automatically for facing wear.

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Continued)

a position as assistant to the general manager or production superintendent. Would consider sales or advertising if sufficient future was offered. Ultimate end, executive administration and management.

0854 ASSISTANT CHIEF ENGINEER Age 33, sixteen years of drafting on chassis design and body supervision.

0855 METALLURGICAL ENGINEER with nine years' experience in plant control work, covering iron, steel, bronze, brass, white metals, aluminum, foundry supervision, heat-treatment, etc., seeks position with firm having difficulties.

0856 TRANSPORTATION ENGINEER Technical graduate, with experience in directing motor transportation, repair and maintenance, desires to locate permanently with some company operating a fleet of motor vehicles. Age 29.

0857 CHIEF ENGINEER of company building high-grade cars with medium production. Has had considerable experience in designing high-speed motor-car and airplane engines and has good working knowledge of modern production.

0858 GENERAL MANAGER, 35 years of age, with practical shop experience and engaged in the automobile and allied industries for fifteen years, desires position with a going firm or one that is being organized. Well versed in production methods, also familiar with layouts and design. Extensive experience in purchasing, also wholesale, retail and export selling.

0859 MECHANICAL AND ELECTRICAL ENGINEER, twelve years' experience, six years in automotive work, inspection, testing and trouble investigation, desires position of responsibility where initiative and resourcefulness will pay.

0861 DESIGNING ENGINEER wishes to connect with a reliable company and develop light or medium capacity truck. Successful experience in this line. Can get maximum results at minimum cost. Technical graduate.

0863 MECHANICAL ENGINEER, with shop training, technical education and about five years' practical experience in production engineering, desires to get into the production end of the automobile business. Twenty-six years of age, single; would prefer to locate in the Middle West.

0864 AUTOMOTIVE ENGINEER with eleven years' experience in designing, testing and manufacturing of motor cars, trucks, engines, transmissions, etc. Also experienced in the design of electrical machinery, automatic lathes, tools, etc., and in shop and production management.

0865 EXECUTIVE with fifteen years' technical and practical experience wishes to get in touch with financial business man or promoter looking for man of ability to organize new business or give new life to an old one. Experience covers all branches of manufacturing. At present with one of the largest automobile parts companies.

0866 DESIGNING ENGINEER desires to make a connection with a passenger-car, truck or tractor organization. Ten years' experience. Thoroughly conversant with

(*Continued on page* 56)

*See announcement at the head of the "Positions and Men Available" column, page 50.

Three Flights From Cairo— All Sparked by

K.L.G PLUGS

THE famous K. L. G. is a mica plug. It is practically indestructible. Neither overheating nor sharp jumps nor drops in temperature can affect its performance.

Every part of it is tested to the limit of engineering knowledge: insulation, electrodes, sleeve, core; to discover flaws of material, workmanship and design.

The best of everything is used in its manufacture regardless of increased cost of time, ability or materials.

This thoroughness is traditionally characteristic of S. Smith & Sons' workmen, engineers and products.

These Facts Explain

why K. L. G.'s have been used by the great majority of pilots on record flights abroad—and why the winner **always** has been Smith-equipped.

And these are the reasons that K. L. G.'s will be submitted promptly to any engineer for merciless testing.

What *Flight* Says About K. L. G. Plugs and Smith's Equipment

"ONCE more Smith's instruments are taking their part in an epoch-making achievement. The Vickers-Vimy Rolls which has been dispatched by *The Times*, and which is piloted by Capt. S. Cockerell and Capt. F. C. Broom, D.F.C., is equipped with the following Smith instruments:—Engine revolution indicators; two types of air-speed indicators—one registering in miles and the other in knots; an altitude recorder; special thermometers—for recording the heat of the oil and the radiators; a time of trip clock; and K. L. G. plugs F12. In the pilot's own story frequent reference is made to the admirable performance of these instruments.

"THE Vickers-Vimy bombing machine purchased by the South African Government, which left Brooklands on Wednesday, February 4, and which is flying to Cape Town, taking the same route as Capt. Cockerell *via* Cairo, is also fully equipped with Smith instruments and accessories, including, in addition to those mentioned above, an eight-day aviation watch; two Husun compasses, type No. 253; and the Smith aviation safety belt.

"ANOTHER machine flying the route to Cape Town—the Airco 16, piloted by Lieut. Cotton and Lieut. McIntosh, which left Hendon on February 6—is also fully equipped with the Smith instruments and accessories and the famous K. L. G. plugs. A specially important fitment is the Smith recording air speed indicator, and the pilots concerned will provide Messrs. S. Smith and Sons (M.A.), Ltd., with a complete set of charts showing the speed of the machine over the entire journey."

Flight is the foremost English aviation engineering journal.

A FEW OF SMITH'S INSTRUMENTS AND ACCESSORIES

Motor Clocks	Spark Plug Testers
Motor Watches	Motor Dash Aneroids
Magnetos	Dash Thermometers
Speedometers	Tachometers
Altimeters	Air Speed Indicators
Wristlet Altimeters	Time-of-Trip Clocks
Aero Compasses, all types	Foot Tire Pumps
Carburetors	Motor Mascots
	K. L. G. Spark Plugs

S. SMITH & SONS, Inc., NEW YORK

J. H. ROSE, Vice President

154 NASSAU ST. BEEKMAN 6217

HEAD OFFICES: S. SMITH & SONS, (MA) LTD., LONDON, W1

Universally Trusted Makers of Instruments since 1841

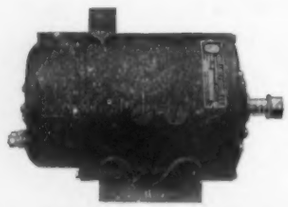
SMITH'S

Leading Makers of Automotive Instruments since 1900

NORTH EAST

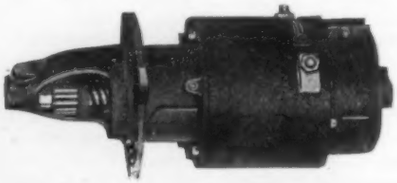
North East Reliability
can be incorporated wherever
S. A. E. Standards
are provided.

Model L Generator
S. A. E. Flange Mounting



Model L Generator
S. A. E. Base Mounting

This same style machine with base removed is suitable for cradle mounting.



Model H Starting Motor
S. A. E. Flange Mounting

NORTH EAST ELECTRIC CO.
ROCHESTER, N. Y.

Atlanta
Chicago
Detroit
Kansas City
San Francisco
New York
Windsor, Ont., Can.

ELECTRICAL EQUIPMENT
FOR AUTOMOTIVE VEHICLES.

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Concluded)

and has specialized in all phases of internal-combustion engine design. Good executive and fully competent to take full charge of design or experimental work. Now in Government service.

0867 ENGINEER Technical graduate with sixteen years' experience on trucks, axles, engines and governors, has successfully filled the position of chief engineer, general superintendent and production manager.

0868 FACTORY MANAGER Technically trained executive who is able to cope with industrial conditions as they are today and at the same time build for the future. Available Sept. 1.

0869 CHIEF ENGINEER, age 37, with eleven years' executive experience in the design and construction of heavy-duty, internal-combustion engines, transmissions and tractors, desires similar or executive position with tractor company. Minimum salary $6,000.

0870 GRADUATE ENGINEER with eleven years' practical experience in designing, experimental and research work on passenger cars, marine engines, trucks and aeronautical engines, is desirous of securing a position as chief engineer with a live company. Good executive, not afraid of hard work. Thirty-two years old.

0871 METALLURGICAL ENGINEER with thirteen years' experience and qualified to handle a staff of men and to investigate, develop and control materials and methods of manufacture which make for efficiency. At present holds responsible position in a prominent organization. Can give the best of references.

0873 ASSISTANT CHIEF ENGINEER Technical man possessed of executive ability. Competent to take entire charge of large or small engineering establishment where thoroughness is essential. Ten years' experience in general engineering projects including tractors, trucks, engines, clutches, transmissions, axles, etc. Widely acquainted in automotive industry. Location no object.

POSITIONS AVAILABLE

1 MECHANICAL DRAFTSMAN familiar with tool designing for work on ignition apparatus. Location Pennsylvania.

2 ENGINEER experienced in conduct of laboratory investigation of internal-combustion engine problems desired for Government station in Virginia.

3 JUNIOR MECHANICAL ENGINEER desired by Government aircraft committee. Location Virginia.

4 DESIGNER AND DRAFTSMEN wanted by Texas motor-truck organization.

5 DESIGNING DRAFTSMAN for work on new tractor drawings. Steady employment with good opportunity to advance. Location Pennsylvania.

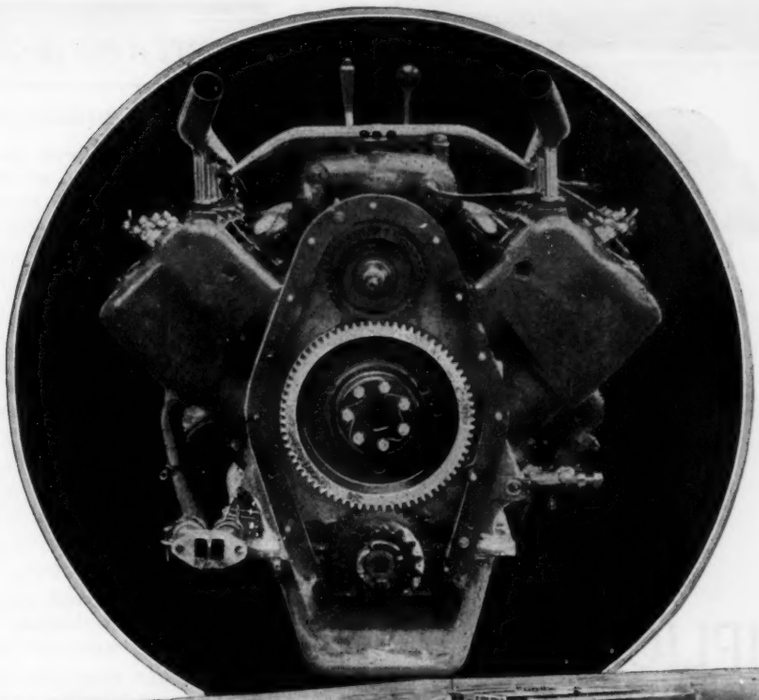
6 EXPORT MANAGER to locate in South America for established passenger car organization. Speaking knowledge of Spanish and French essential.

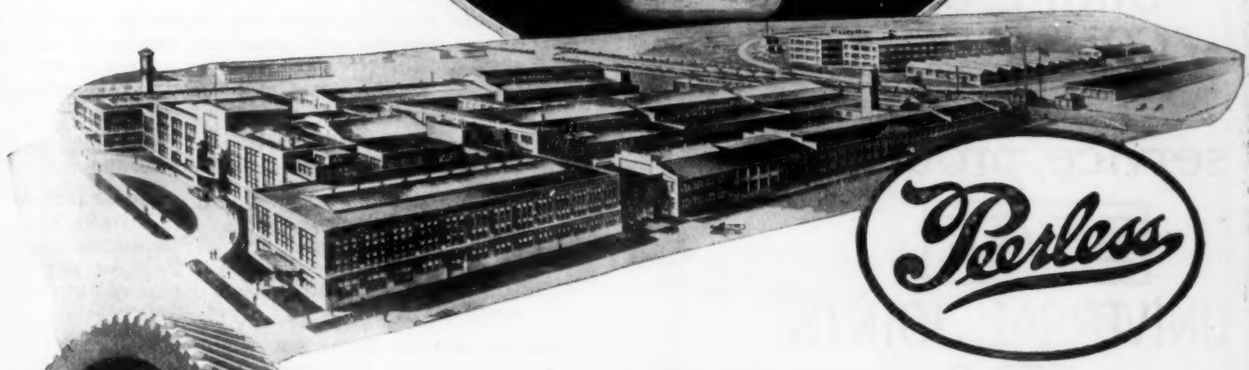
7 PURCHASING AGENT Must be of proved ability in his line and familiar with the sources of both raw and finished material for a high-grade assembled truck to be built by newly formed company located in Ohio.

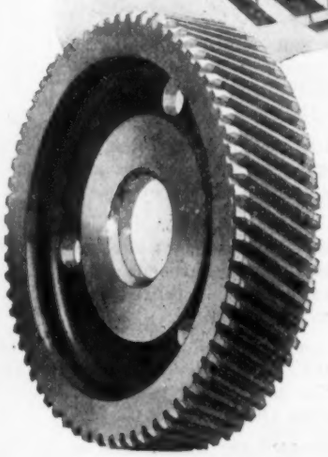
8 SALES MANAGER Experienced and successful truck sales manager. Must be a practical and experienced

(*Continued on page* 58)

*See announcement at the head of the "Positions and Men Available" column, page 50.







Silent Timing Gear

With Peerless, as with many other makes of first-class automobile engines, Fabroil Gears are being used as the main timing gear. Because of the successful operation of Fabroils, helical gearing on front ends has made considerable gain within the last two years.

Have you ever tried one of these raw cotton gears? If you haven't you have a surprise in store for you.

Fabroils are made in all shapes and sizes—have been furnished from one to thirty inches in diameter.

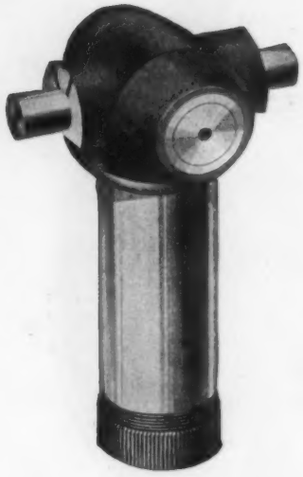
Send for booklet 48703 J.

FABROIL GEARS

General Electric Company

General Office
Schenectady, N.Y.

Sales Offices in
all large cities



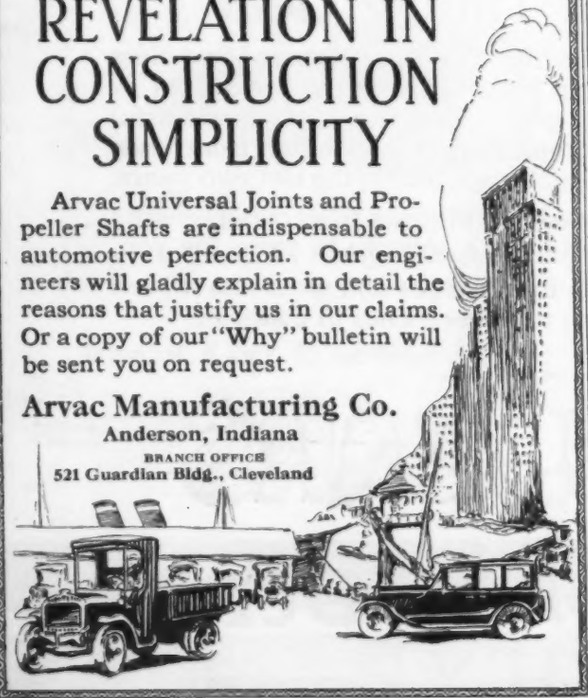
SIMPLICITY
of CONSTRUCTION
reduces
service problems

ARVAC
TRADE MARK

UNIVERSAL JOINTS
are a
REVELATION IN
CONSTRUCTION
SIMPLICITY

Arvac Universal Joints and Propeller Shafts are indispensable to automotive perfection. Our engineers will gladly explain in detail the reasons that justify us in our claims. Or a copy of our "Why" bulletin will be sent you on request.

Arvac Manufacturing Co.
Anderson, Indiana
BRANCH OFFICE
521 Guardian Bldg., Cleveland



POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (*Continued*)

truck man with the necessary personality and ability to build up a strong selling organization and to promote the sales of a high-grade truck. Salary in accordance with ability and experience. Location Ohio.

9 LAYOUT MAN experienced on engine work. Good salary. Location Illinois.

10 ASSISTANT EDITOR for Chicago automotive publication. College graduate with some experience and if possible one with garage experience preferred.

11 DRAFTSMEN AND MACHINE-TOOL DESIGNERS desired by Cleveland motor-car company.

12 COLLEGE GRADUATE for time study work. Technical man with one or two years' shop experience preferred. Location Ohio.

13 ENGINEER familiar with up-to-date truck designs and practice to take charge of engineering department for Michigan company.

*14 ENGINEER with experience on truck assembly. Location Pennsylvania. State age, married or single, education, experience, salary and references.

15 WORKS MANAGER for modern up-to-date factory making accessories and specialties, employing about 100 men. Must have experience on automatic screw machinery, punch presses, assembling, etc. Location New Hampshire.

16 RATE SETTERS AND ESTIMATERS possessing tact and initiative wanted by New England machine-tool builder.

17 DESIGNING ENGINEER, technical graduate with two or more years' experience on tractors or trucks, to affiliate with newly organized firm of consulting engineers. Machine-shop experience desirable. An opportunity is offered to expand into the business end of the work. Location Wisconsin.

18 EXPERIENCED DETAILERS on automobile work. Permanent position and excellent opportunity for advancement. Location Michigan.

*19 LAYOUT DRAFTSMAN AND DESIGNER experienced on motor, axle and transmission design desired by one of the largest producers of passenger cars and trucks in Middle West. Give outline of experience and salary acceptable.

20 DESIGNING ENGINEER experienced in automotive equipment, preferably gasoline and kerosene engines. Good opportunity for advancement in large progressive organization. Location Michigan.

21 SALES MANAGER for company building 25,000 light high-grade cars per year. Must have held position in reputable organization and have proved ability to lay out territory. Location Ohio.

22 FACTORY SUPERINTENDENT for automobile company in Ohio. Must have good record and be thoroughly acquainted with big production methods.

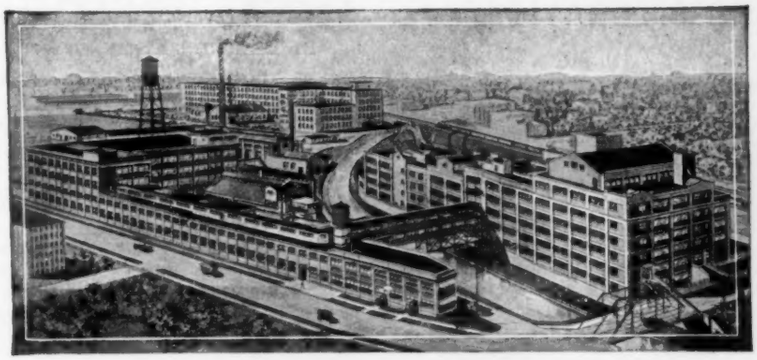
23 PURCHASING AGENT for passenger-car factory. Must come well recommended. State salary required and experience. Location Ohio.

24 ACCOUNTANT for Ohio automobile company. Must have a thorough knowledge of factory accountancy and corporation finance. State salary required and give full particulars of experience.

25 DESIGNING DRAFTSMEN on electrical apparatus. Location Ohio.

(*Continued on page* 60)

*See announcement at the head of the "Positions and Men Available" column, page 50.



The ten-acre plant of the New Process Gear Corporation

Right Gears

No matter what types of gears you need for your car, truck or tractor, we make them all and make them right.

New Process equipment and methods are highly developed to produce gears in large volume and, above all, with uniform exactness.

Automatic machines to cut teeth with precision, equipment to heat-treat gears correctly and machines to prevent them from warping, thoroughness in every detail and extreme care in inspection—these are what make New Process Gears *right*. That is why you will obtain

Quality—Quantity—Quickness

New Process Gear Corporation

Syracuse *Member of the* **New York**

AGMA

New Process Gears

TO THE MEMBERS

FROM THE MEETINGS COMMITTEE

The S. A. E. Summer Meeting at Ottawa Beach, on Lake Michigan, June 21st to 25th, will be without doubt a record meeting as regards both attendance and interest.

The technical sessions are as follows:

Fuel	Tuesday, June 22nd
Transportation	Wednesday, June 23rd
Farm Power	Thursday, June 24th
Production	Friday, June 25th

After reviewing replies from prominent engineers and manufacturing executives to questions relative to fuel, transportation, production and farm power, it is safe to predict that there will be no lack of constructive suggestions dealing with these pressing problems. You should be there if at all interested in the condition of the industry brought about by such elements as high fuel consumption, inadequate highway appropriations, labor psychology and transportation expediencies, and wish to hear able discussions dealing with these matters.

Besides, the sports events have been doubled in number and great competition and amusement is expected in these recreational features.

We wish to emphasize the importance of the Standards Committee and Business Meeting Monday, June 21st.

Over 95 per cent of total available accommodations have been applied for.

Special transportation has been arranged for members residing at various important centers.

If you are planning to attend the Summer Meeting, make your reservations now to insure accommodations.

Faithfully yours,

MEETINGS COMMITTEE

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

26 SALES MANAGER for company manufacturing staple product sold only to large automobile accessory distributors and car manufacturers. Must be personally and favorably known to the trade.

27 DESIGNING ENGINEER for Wisconsin passenger-car firm.

28 MANUFACTURER OF ACCESSORIES for trucks and tractors, near New York City, wishes to engage young man with engineering degree having three to five years' experience in both practical and office work in connection with engines, automobiles, trucks or tractors, for assistant to executive in charge of nation-wide service organization.

29 SALES MANAGER'S ASSISTANT Must be experienced in handling heavy correspondence and in supervising a force of traveling men. Automobile experience desirable but not essential. An opportunity for advancement in a great automobile selling organization.

30 GRADUATE MECHANICAL ENGINEERS with automobile experience for work on designing in connection with motor trucks

31 DRAFTSMAN OR ENGINEER for work as lay-out man on tractors. Should be experienced in automotive lines. Give full references. Location California.

32 FOREMAN IN MACHINE SHOP of an automobile factory producing a high-grade car. One capable of handling men and familiar with modern methods of production and who has had experience in jig and tool designing.

33 SUPERINTENDENT OR PRODUCTION MANAGER in an automobile plant building high-grade cars. Must be personally able to supervise production, route work and materials through the plant and have experience in modern methods of cost reduction.

34 ENGINEER familiar with aviation engine design. Location near New York City.

35 DRAFTSMAN with some experience on gasoline engines and electrical work. Location New Jersey.

36 FIRST-CLASS DETAIL DRAFTSMAN required by rapidly growing Eastern automobile plant.

37 CHIEF ENGINEER Technical graduate with ten or fifteen years' experience. Position now open with prominent Middle West parts manufacturer. Must be an executive familiar with both designing and shop practice. Salary in keeping with experience and ability.

38 DRAFTSMEN on airplane work. Location near New York City.

39 MECHANICAL DRAFTSMAN with good experience. Location New Jersey.

40 ELECTRICAL ENGINEER to teach automotive electricity in high-grade institute. Must have some practical experience and ability to teach. Location Chicago.

41 PRODUCTION SUPERINTENDENT or works manager for automobile body plant in northern Indiana. Must be able to handle men, bring up production to a maximum and keep it there.

625 OHIO AUTOMOBILE MANUFACTURER has openings for aggressive, well-educated young men capable of developing into executives and willing to start at modest salary. State age, height, weight, married or single, education, experience, knowledge of mechanical drafting and blueprint reading, service record, present salary, salary expected at start, whether any dependents, and if preference is for purchasing, sales, accounting, engineering or production.

(*Continued on page* 62)

*See announcement at the head of the "Positions and Men Available" column, page 50.

Transmits the power without the shock

The strain on the universal joint is intensified with every irregularity of the road

MUDHOLES—sharp turns—steep hills—worn-out roads—all test the universal joint.

At every irregularity in the road the universal joint must adapt itself to abrupt changes in the angle of the drive shaft.

Metal joints wear loose under this severe strain. They transmit road shocks and engine shocks.

Cushioning the shocks and strains

To save a car this severe wear and tear, the Thermoid-Hardy Universal Joint has been designed. Built of flexible fabric discs, it absorbs the blows that rack the gears and bearings. The Thermoid-Hardy Joint transmits the power without the shock.

Having no metal-to-metal wearing surfaces, the Thermoid-Hardy Joint cannot wear loose. It requires no lubrication—no constant attention.

Adopted by leading manufacturers

More than fifty leading manufacturers are using the Thermoid-Hardy Universal Joint as standard equipment. It has stood severe tests for endurance—in many cars running 60,000 miles without replacement or adjustment of any kind.

Let our staff of engineers explain how practical and economical installation may be accomplished in your car.

The new book "Universal Joints—Their Use and Misuse," giving details of construction, records of performance, tests for strength of the Thermoid-Hardy Universal Joint, will be sent you upon request.

Thermoid Rubber Company

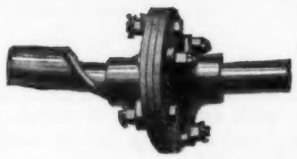
Sole American Manufacturers

Factory and Offices: Trenton, N. J.

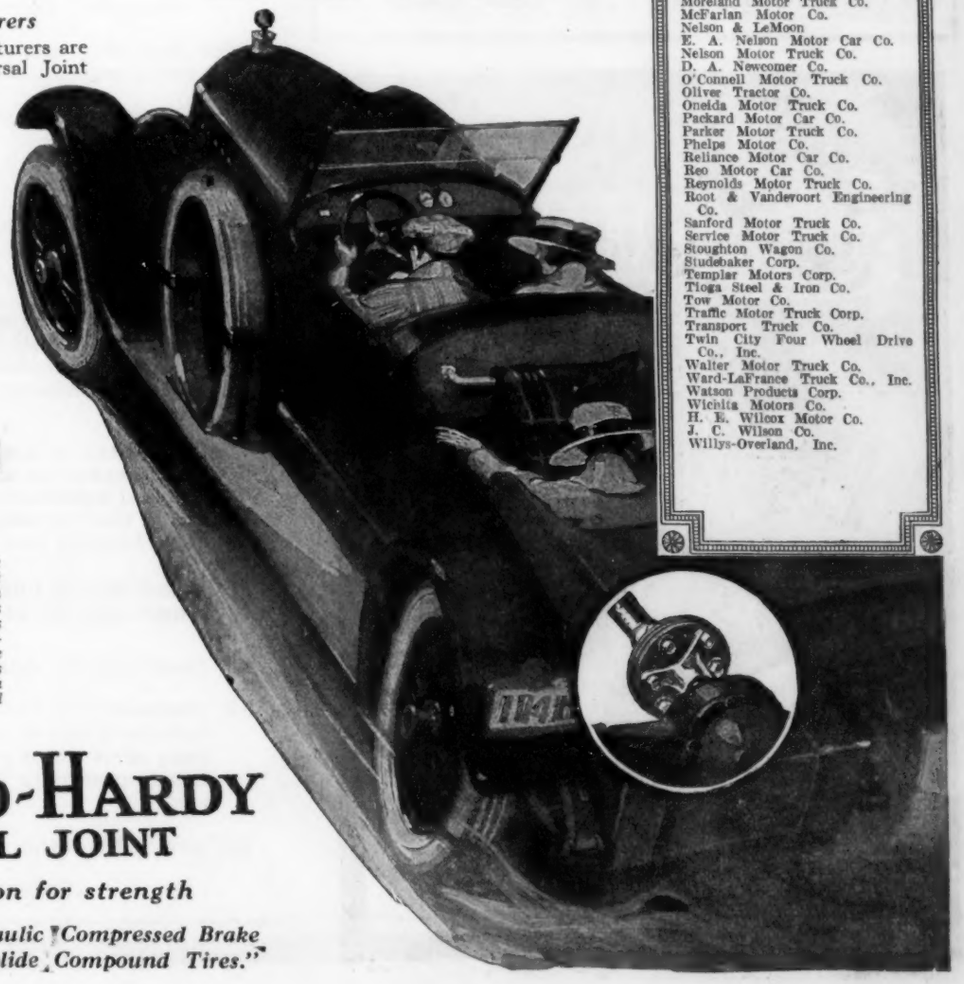
New York Chicago San Francisco Detroit
Cleveland Atlanta Philadelphia Pittsburgh
Boston London Paris Turin

List of users

American British Mfg. Co.
Anderson Motor Co.
The Autocar Co.
Available Truck Co.
Barley Motor Car Co. (Roamer)
Briscoe Motor Corp.
Capitol Motors Corp.
Jas. Cunningham Son & Co.
Crow-Elkhart Motor Co.
Dart Truck & Tractor Corp.
Diamond T Motor Car Co.
Doane Motor Truck Co.
Fageol Motor Car Co.
H. H. Franklin Mfg. Co.
Garford Motor Truck Co.
Gramm-Bernstein Motor Truck Co.
Hebb Motors Co.
Hendrickson Motor Truck Co.
Holt Mfg. Co.
Indiana Motor Truck Co.
International Harvester Co. of A., Inc.
International Motor Co.
Kentucky Wagon Mfg. Co., Inc.
King Motor Car Co.
King Zeller Co.
Larrabee-Deyo Motor Truck Co., Inc.
Lexington Motor Co.
Locomobile Co. of America
Maxwell Motor Corp.
Menominee Motor Truck Co.
Mercer Motors Co.
Moreland Motor Truck Co.
McFarlan Motor Co.
Nelson & LeMoon
E. A. Nelson Motor Car Co.
Nelson Motor Truck Co.
D. A. Newcomer Co.
O'Connell Motor Truck Co.
Oliver Tractor Co.
Oneida Motor Truck Co.
Packard Motor Car Co.
Parker Motor Truck Co.
Phelps Motor Co.
Reliance Motor Car Co.
Reo Motor Car Co.
Reynolds Motor Truck Co.
Root & Vandervoort Engineering Co.
Sanford Motor Truck Co.
Service Motor Truck Co.
Stoughton Wagon Co.
Studebaker Corp.
Templar Motors Corp.
Tioga Steel & Iron Co.
Tow Motor Co.
Traffic Motor Truck Corp.
Transport Truck Co.
Twin City Four Wheel Drive Co., Inc.
Walter Motor Truck Co.
Ward-LaFrance Truck Co., Inc.
Watson Products Corp.
Wichita Motors Co.
H. E. Wilcox Motor Co.
J. C. Wilson Co.
Willys-Overland, Inc.



In building up the flexible fabric disc the several layers of fabric are put together so that the strands in each piece run in a different direction. This patented fanwise construction provides the greatest tensile strength. In a laboratory test made recently at Purdue University the drive shaft, itself, was twisted at a total stress of 21,700 inch pounds without injury to the universal joint.



THERMOID-HARDY UNIVERSAL JOINT

Fanwise construction for strength

Makers of "Thermoid Hydraulic Compressed Brake Lining" and "Thermoid Crolide Compound Tires."

DO you know what that means to the car owner whose car is "Exide" equipped?

It means he is getting a specialized product backed up by over a generation of specialized experience. It means he is getting the *best* that the largest maker of storage batteries in the world can produce. It means he is getting *the* starting battery—*proved right* in every detail—construction, performance, durability.

THE ELECTRIC STORAGE BATTERY CO

The largest manufacturer of Storage Batteries in the World

1888 PHILADELPHIA, PA. 1920

New York, Boston, Washington, Minneapolis, Denver, Detroit, San Francisco, Kansas City, Chicago, Cleveland, Atlanta, Pittsburgh, St. Louis, Rochester.

Special Canadian Representatives:
Chas. E. Goad Engineering Co., Ltd., Toronto, Montreal.

A TWIST OF THE WRIST—

SIMPLE, EXPEDITIOUS, UNFAILINGLY EFFICIENT AND INEXPENSIVE

A new patented, quick-acting dust cap which does away altogether with the long and sometimes difficult process of screwing on or off.
It slips over the valve-stem and locks with one turn. When you want it to come off—and not till then—one turn in the other direction unlocks it.

Price, 50 Cents per Set of Four
at your dealer's or
A. SCHRADER'S SON, INC.
Brooklyn, N. Y.

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

704 ELECTRICAL REPAIRMEN on automobile starting motors and generators desired for Eastern service stations.

731 MECHANICAL DRAFTSMEN with technical training, preferably with motor truck or automobile experience.

799 PRACTICAL CHEMIST wanted by a Massachusetts fabric manufacturer.

855 DESIGNING DRAFTSMEN desired for layout work on ordnance and tractor work. Location Illinois.

858 PUNCH AND DIE DESIGNER for New Jersey electrical manufacturer.

862 TOOL DESIGNERS capable of designing jigs, tools and fixtures for economical manufacture. Prefer men who are up-to-date and progressive in methods and practical. Location Illinois.

890 ENGINEERS with experience in experimental work are desired by an Illinois engine builder.

891 ASSISTANT CHIEF ENGINEER, technical graduate with ten or fifteen years' experience, including work in designing and research and the ability to express ideas properly in writing. Experience on internal-combustion engines, pumps and electrical machinery is desirable but not absolutely essential. Salary commensurate with ability. Opportunity unlimited. Location Chicago.

892 DRAFTSMEN AND EXPERIMENTAL MEN needed by a Wisconsin engine builder.

*893 INDUSTRIAL ENGINEERS WANTED. A large firm of industrial engineers is constantly on the lookout for the highest grade men. Technical education advantageous but not essential. Must have successful executive manufacturing record. Qualifications to include: Organization, management, production processes, industrial relations, employment, cost accounting and a practical knowledge of the operation of machine tools, metal or woodworking or both. Men who have been general managers, works managers, factory managers, superintendents and production managers are desired. Salary commensurate with ability. Applicants will be located in different localities for several months at a time.

899 DRAFTSMAN with a thorough knowledge of the design and manufacture of small motors, generators and mechanical appliances, with experience in factory methods of manufacture, detail drafting, design and checking. Location New York City.

914 DESIGNERS AND CHECKERS on automobile axles for passenger cars, trucks and trailers. Location Cleveland.

938 DRAFTSMEN for detail work by Illinois tractor builder.

942 EXPERIMENTAL LABORATORY ASSISTANT. Young man, technical graduate preferred, to assist in laboratory of large parts maker and gear manufacturer. An exceptional opportunity for the right man. Location Indiana.

943 MARINE DESIGNING DRAFTSMAN. Location New Jersey.

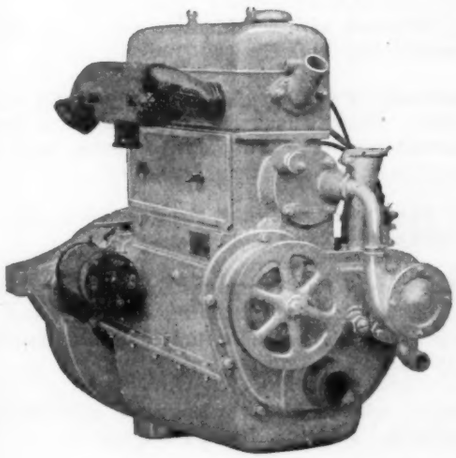
(*Continued on page* 64)

*See announcement at the head of the "Positions and Men Available" column, page 50.

Weidely Bulldog

4-Cylinder Valve-in-Head Motors

The Speed Wagon Demands an Unusual Type of Motor



GOOD roads—pneumatic tires—the growing need for quick, sure overland transportation—these are conditions which bear heavily on the modern trucking problem.

The manufacturer must supply an engine capable of operating economically—delivering the greatest possible power output per unit weight of fuel—yet with sufficient ruggedness and stamina for hauling truck loads at passenger car speeds.

For years we have been supplying high speed motors built for heavy duty service. Their record of performance is unsurpassed by any motor in any service.

The Type MAT combines all the essential requirements for efficient speed wagon service, namely: valves in head for maximum utilization of power generated in the cylinders, fairly high gas speeds in the passages, bore and stroke ratio of 1-5/10 to 1 and proportioning of parts to permit operation at reasonably high speeds continuously. These features have been thoroughly tested and proved in the type MAT.

All the "bugs" have been worked out in actual use over a long period of years.

Weidely motors are in large production, our plant being equipped with the most modern machinery necessary for the manufacture of this particular model. Correspondence with our engineers is invited. Write for full technical description and other interesting data.

SPECIFICATIONS

Bore, 3¾ in.; stroke, 5½ in.; piston displacement, 243 cu. in.; overhead valves; force feed lubrication; centrifugal water pump.

WEIDELY MOTORS COMPANY

Main Office and Factory: Indianapolis, Ind., U. S. A.

New York: John M. Steinau, 2 Columbus Circle

San Francisco: Adam-Hill Co., 96 Ninth St.

INTERNATIONAL METAL HOSE CO., Inc.

We Can Make Prompt Deliveries

Manufacturers of
FLEXIBLE CARBURETOR, EXHAUST AND WIRE CASING

Also
STEEL OIL TUBING
FLEXIBLE
METAL HOSE AND TUBING

For all purposes

Send us your inquiries

Harvard Ave. at E. 103
CLEVELAND

The Silent Partner

A quiet, indispensable influence and power

The New Model B

Universal Joints

Incorporate a *Brute Strength* and *Unequalled Service*, functioning as the invaluable "*Silent Partner*" where dependable automotive power counts.

The *Over-Sized Bearings* in Model B Universal Joints are positively lubricated by a constant oil distribution. It is a guarantee of unfailing service.

Catalog on request

Blood Bros. Machine Co.

Pioneer Builders of Universal Joints

Allegan **Michigan**

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

945 ELECTRIC VEHICLE TESTER AND INSPECTOR for road testing and workmanship inspection on chassis and bodies. Location near New York City.

946 DESIGNER AND DRAFTSMAN for work on automobile chassis. Location near New York City.

*948 FIELD RESEARCH ENGINEER Young man, with good physique, address and sales ability, is desired by an established accessory firm for experimental work on truck and tractor engines in the field. State education, experience, age and salary. Location Southwest.

949 AERONAUTIC DRAFTSMAN experienced in car and fuselage details. Should be capable of developing original ideas and assuming a responsible design position shortly.

950 DRAFTSMAN familiar with body design. Location Illinois.

951 DRAFTSMAN for layout work on automobile trucks. One with electric vehicle experience preferred. Location Connecticut.

956 LAYOUT MEN for Southern truck company.

958 TRUCK DESIGNER with considerable experience desired by Missouri truck builder.

964 SUPERINTENDENT OR PRODUCTION MANAGER for carbureter plant. Must be personally competent to handle the manufacture of small parts, organize inspection and route work and materials.

966 LAYOUT DRAFTSMAN with first-class experience for Detroit automobile builder.

*970 ENGINEER to represent several established trade publications. Some technical training desirable and familiarity with trade viewpoint and publication business essential. Location Detroit.

974 DRAFTSMAN with some knowledge of electricity or magneto work. Location New York City.

975 DESIGNER AND LAYOUT MAN with truck or tractor experience wanted at once. Only high-class man desired. Location Middle West.

979 EXPERIENCED CHECKER on automobile engine, axle and transmission work for established truck builder. Location central New York.

*980 ESTIMATERS OR OPERATORS on automobile axle, engine and transmission parts from blueprints for various machine operations. Permanent positions with old well-established company for men who are thoroughly experienced in the latest and most approved production methods, jig, fixture, tool and gage design and time study work. Location central New York.

981 LAYOUT MEN AND DETAILERS for automobile and truck chassis work near New York City.

(*Continued on page* 66)

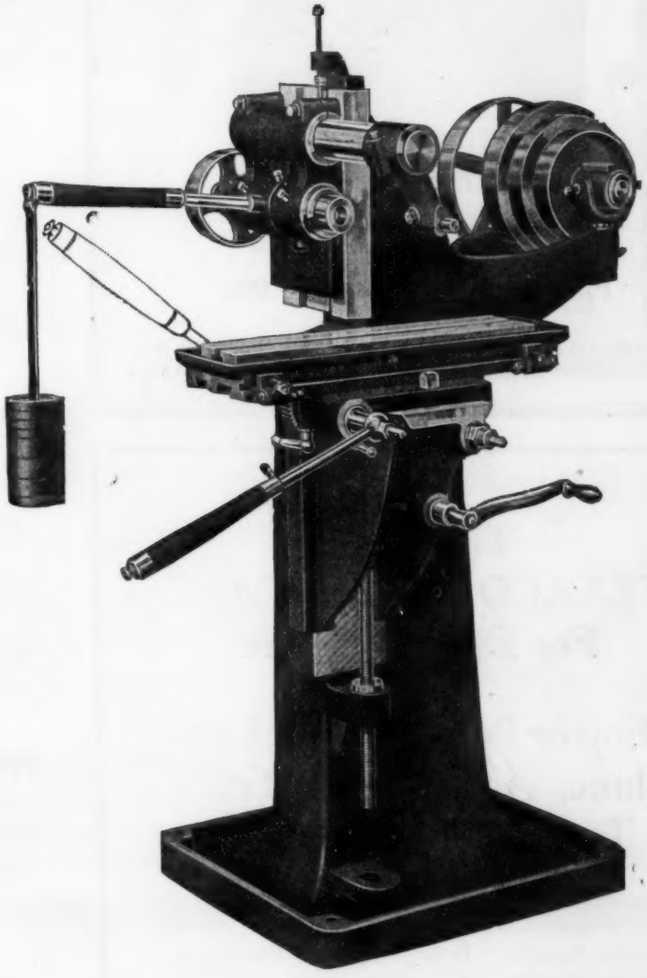
*See announcement at the head of the "Positions and Men Available" column, page 50.

THE "WHITNEY" HAND MILLING MACHINE

THOUSANDS IN USE

For a great many years we have devoted practically all of the energy of our Machinery Department to the production of this one machine, which long ago superseded all other sizes and styles of hand millers previously made by us.

The design is the result of years of study and experiment, and the wonderful sale of the machine is a tribute to the excellence of its construction, the high character of its workmanship, and the accuracy and volume of its output. Adverse criticism is practically unknown.



PROMPT DELIVERIES

THE WHITNEY MFG. CO., Hartford, Conn.

CHAINS KEYS AND CUTTERS HAND MILLING MACHINES

Foreign Agents: Burton, Griffiths & Co., Ltd., London. Fenwick Freres & Co., Paris, France
Rylander & Asplund, Stockholm, Sweden

MARKO
STORAGE BATTERIES

ESTABLISHED 1907

The Ultimate in Storage Battery Engineering

Highest in Quality

Longest in Life

Manufactured by

PAUL M. MARKO & CO., INC.

Main Office and Works

1402-1412 ATLANTIC AVE. BROOKLYN, N. Y.

INTERESTING LITERATURE WILL BE SENT ON REQUEST

There is a TEXACO LUBRICANT For Every Purpose

Shop or Power Plant, Aeroplane, Automobile, Truck Tractor or Motor Boat

Our magazine LUBRICATION is a part of Texaco Service. It is devoted to Lubricants and their application, exclusively, and sent Free to all interested in the subject.

You can get a copy each month by asking us to put your name on our mailing list.

The Texas Company

17 Battery Place, New York City

New York Chicago Houston

Offices in Principal Cities

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Concluded)

982 BODY DRAFTSMAN with good experience. Location Illinois.

983 YOUNG ELECTRICAL ENGINEERS for development and research work. Location Ohio.

984 SALESMEN with engineering experience wanted by established tractor manufacturer. Men who can sell machinery, have ability to organize and develop special industrial markets and desire a permanent connection desired.

987 MANAGER for established business. Must be high-class executive and practical tool and die maker. Qualifications must include the ability to get good production. In replying give experience and references. Location Detroit.

988 CHIEF INSPECTOR with several years' practical experience in machine shop, foundry and forge work. Time study experience desirable. Location Ohio.

989 YOUNG ENGINEER experienced in the installation of production systems. Location Ohio.

990 DRAFTSMAN experienced in layout of trucks or passenger cars. Location New Jersey.

991 MECHANICAL DRAFTSMEN wanted by a large automobile firm located in Wisconsin; men with technical experience who have had automobile or truck experience.

992 SHOP EXECUTIVE familiar with quantity production in small metal parts and all phases of the selection and arrangement of machinery, jigs, tool design and direct supervision of manufacturing. Location Wisconsin.

993 ENGINEER to take charge of all designing work, drafting room and blueprint and specification departments. Location central New York.

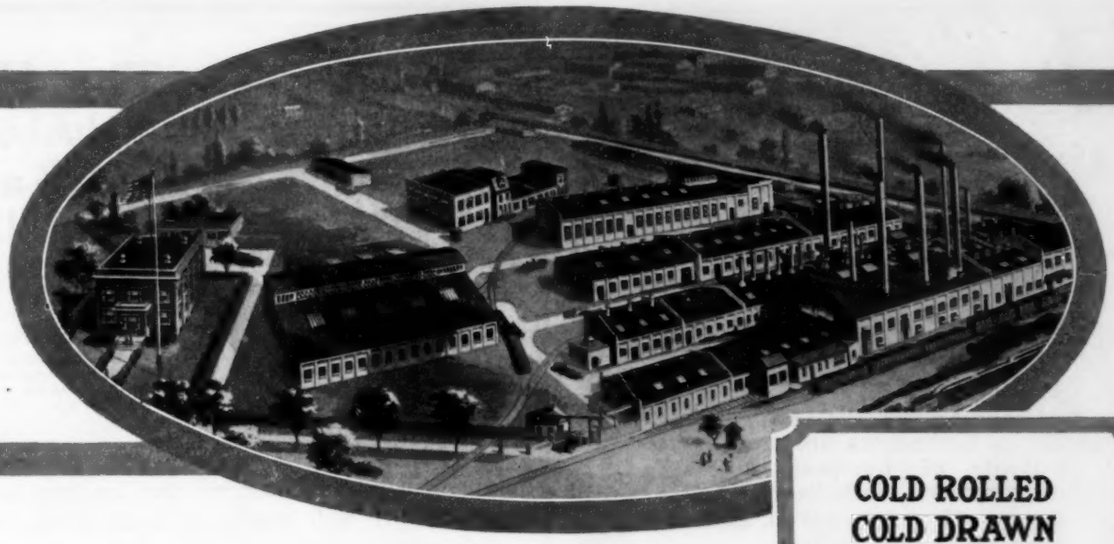
994 ENGINEER with good technical and practical training on light passenger cars or motorcycles. Location Massachusetts.

996 TRANSPORTATION ENGINEER desired by Eastern motor car company. Must be thoroughly experienced in writing sales data, bringing out special features of truck design and be thoroughly familiar with transportation costs and problems.

998 PRESS ROOM AND TOOLROOM FOREMAN for shop making medium and small stampings in light and heavy gage steel. Shop capacity is being increased and offers a good opportunity for two first-class men. Location Middle West.

999 ENGINEER to take charge of new passenger-car plant in India. Man capable of purchasing machinery and necessary material, assembling the car and putting it into production wanted.

*See announcement at the head of the "Positions and Men Available" column, page 50.



COLD ROLLED
COLD DRAWN
ALLOY STEEL
BESSEMER SCREW STOCK
OPEN HEARTH STEEL
BRAKE BAND STEEL
SPECIAL SHAPES

Keeping Faith Under Prevailing Conditions

EVERY one knows that the steel situation today precludes the possibility of prompt delivery.

Yet under the existing abnormal conditions we are doing our utmost—straining every fibre to serve our customers. We know the advantage of preserving good will—we know the need of building for the future—WE MUST KEEP FAITH.

You can help relieve the tension by anticipating your requirements and placing your orders now for later deliveries.

With this co-operation we can, in a small way, overcome the prevailing handicap and keep your faith.

LANCASTER STEEL PRODUCTS CORP.
MILLS—LANCASTER, Pa.
WESTERN SALES OFFICES: CHICAGO AND DETROIT
EASTERN SALES OFFICES: HARTFORD, CONN.

LANCASTER STEEL

These Facts Are Significant:

That Zenith Carburetors are used by the majority of European automobile manufacturers, including Delage, Peugeot, Gregoire, DeDion, and many other well-known makers.

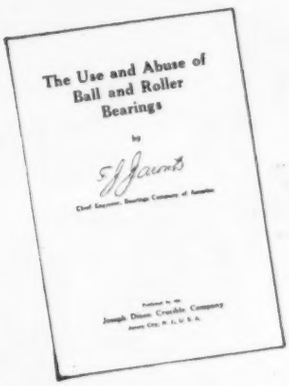
That Zenith is used by more than ONE HUNDRED American manufacturers of passenger and commercial cars.

Zenith means Power, Economy and Reliability.

Zenith Carburetor Company

Chicago DETROIT New York

London, England Lyon, France Turin, Italy


The Use and Abuse of Ball and Roller Bearings
by
F. J. Jarosch
Chief Engineer, Bearings Company of America
Published by the Joseph Dixon Crucible Company
Jersey City, N. J., U. S. A.

The Use and Abuse of Ball and Roller Bearings

By F. J. JAROSCH
Chief Engineer
Bearings Company of America

This booklet is being used today as an authority by many of the leading engineers. It will assist in finding the true cause of trouble and will tell how to overcome it.

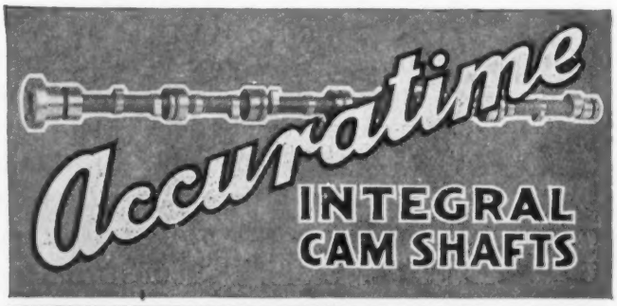
"The Use and Abuse of Ball and Roller Bearings" should be a part of every engineer's library.

Please send for Booklet 95-Z—it's free.

Joseph Dixon Crucible Co.
Jersey City, N. J.
Established 1827

You get the kind that you want when you want them if your specifications call for Stromberg-Carlson permanent magnets. We specialize in the quantity production of high quality permanent magnets for the electrical and automotive industries. Let us figure upon your requirements.

STROMBERG-CARLSON TEL. MFG. CO.
ROCHESTER, N.Y.U.S.A.



Built By
MUSKEGON MOTOR SPECIALTIES COMPANY
MUSKEGON, MICHIGAN.

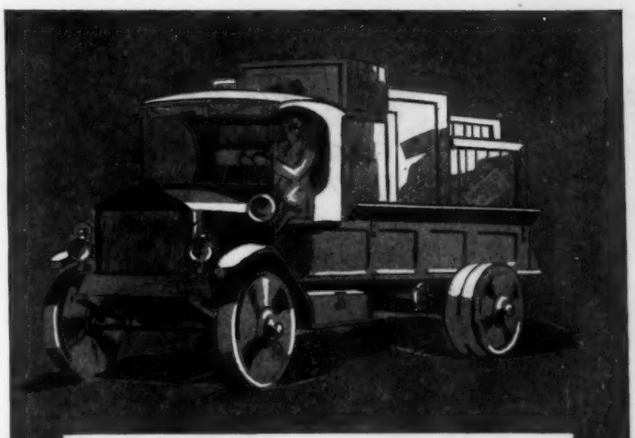
By Reputation – "The Best Cam Shafts Made"

Johns-Manville Automotive Equipment

Non-Burn Asbestos Brake Band Lining.
Johns-Manville Brake Lining for Ford Cars.
Johns-Manville Clutch Rings and Facings.
Johns-Manville Speedometers.
Johns-Manville Speedometers for Ford Cars.
The Jones Recorder for Commercial Vehicles.
Johns-Manville Hub Odometer.
Johns-Manville Hub Odometer for Ford Commercial Vehicles.
Johns-Manville Auto Tape.
Johns-Manville Packings for Automobiles.
"Noark" Auto Lighting Fuses and Clips.

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

H. W. JOHNS-MANVILLE CO.
New York City
10 Factories—Branches in 63 Large Cities



In the Truck

The fact that it is unaffected by oil or grease, makes *VUL-COT* Fibre a serviceable material for use as cylinder gaskets, crank case gaskets and smaller parts.

For facings of friction clutches and for brake bands *VUL-COT* Fibre meets every condition of reasonable use.

VUL-COT Fibre

(A higher development of cotton vulcanized fibre)

Because of the ease with which it can be turned, tapped and threaded, and the smooth, even finish which it takes, it is well suited for the making of handles, cranks, etc. Besides the parts named there are hundreds of others that are made or can be made of *VUL-COT* Fibre.

Truck and automobile manufacturers will be interested in our booklet on the electrical and mechanical uses of *V* - Fibre. Send for it.

VUL-COT Fibre is sold in sheets, rods and tubes, or machined to your specifications.

AMERICAN VULCANIZED FIBRE CO.
521 Equitable Bldg., Wilmington, Del.

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Are prepared to meet all S. A. E. Open-Hearth Alloy Specifications

Iron and Steel Bars and Shapes, Tacks, Nails, Rivets and Wire Products.

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"JASCO" SAFETY FIRST TANK

WHEN you see a "Jasco" Tank on a car you can recognize it at once as a quality car. That the manufacturer is buying the best that can be had—a tank which can't leak, a tank which "stands up" strongest where service is hardest. A tank that means lasting service, positive protection and greater fuel economy.

Made of seamless drawn steel, tested and proved perfect in every detail of construction. Send for booklet and detailed information.

We are prepared to handle contracts for deep drawn steel work. Send specifications.

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Car Makers Tests Prove Gilmer Superiority

Car manufacturers can't afford to take chances with fan belts—too much of the car's performance depends upon fan belt efficiency. And so they put fan belts to the most rigorous tests for heat resistance, oil and moisture resistance, shrinkage, stretching, slippage.

But manufacturers' tests bring remarkable unanimity of results—shown by the fact that over 80% of the automobiles built in America today are Gilmer-equipped at the factory.

The following Gilmer Woven Products are widely used as regular equipment:

Woven Endless Fan Belts
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All Gilmer Products are Solid Woven. They are produced under the supervision of a skilled engineering department and are proving their superiority in service every day.

Consultation is invited.

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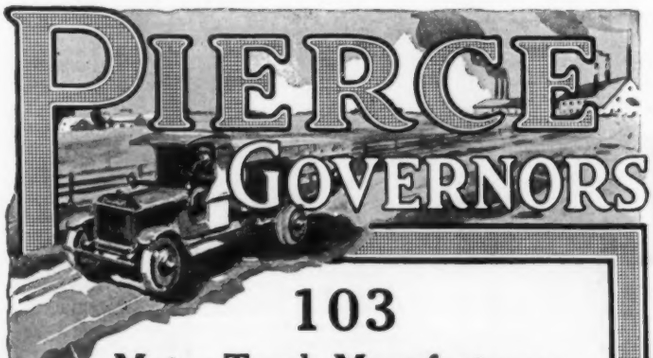
Gilmer WOVEN PRODUCTS PHILADELPHIA

THE dependence more than 1,250,000 motorists place in the Nagel Ammeter is born of satisfactory personal experience.

The Nagel Ammeter is standard equipment on Austin, Auburn, Anderson, American, Beggs, Bell, Briscoe, Bour Davis, Chevrolet, Curtis, Collier, Handley-Knight, Luverne, Maxwell, Mitchell, Moore, Oakland, Oldsmobile, Jackson, Overland, Peugeot, Pan, Piedmont, Security, Stanwood, Stephens, Studebaker, Vogue and Willys-Knight passenger cars, and Atlas, Collier, Commerce, Gramm-Bernstein, Garford, G. M. C., Kearns-Dughie, Nash, Nelson, Olds, Republic and Stewart motor trucks. Also endorsed by use by the makers of the Auto-Lite, Bijur, C. A. Vanderbilt, London, England, and Remy Starting and Lighting Systems.

THE W.G. NAGEL ELECTRIC CO.
TOLEDO OHIO

NAGEL AMMETER



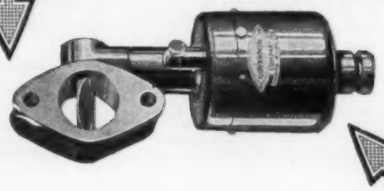
103
Motor Truck Manufacturers
Now Furnish Pierce Governors as Standard Equipment

The overwhelming endorsement that the truck industry has given Pierce Governors proves conclusively two things:

—it proves that these manufacturers recognize the necessity of automatic speed control if their trucks are to deliver maximum service at minimum cost.

—and it proves beyond any question of a doubt the superiority of Pierce Governors.

The Pierce Governor Company
Anderson, Indiana



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Send Us Your Blueprints and Specifications

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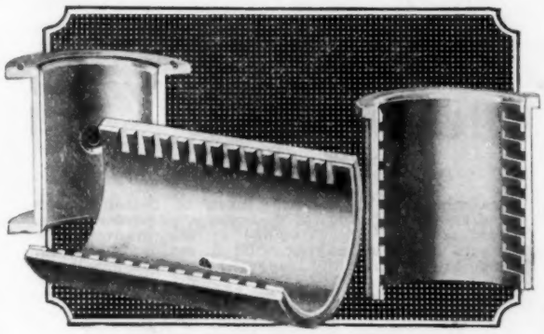
New Freedom, Pa.



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"Die-Cast by Doehler"

Quality first, last and always is the reason why Doehler Die-castings have always stood supreme. They are the accepted standard in the automotive industry—as in every other.

You can put your trust in Doehler.

THE WORLD'S LARGEST MANUFACTURERS OF DIE CASTINGS

DOEHLER DIE-CASTING CO.

MAIN OFFICE AND EASTERN PLANT BROOKLYN, N.Y. CENTRAL PLANT TOLEDO, OHIO. WESTERN PLANT CHICAGO, ILL.

SALES OFFICES IN ALL PRINCIPAL CITIES

DDC-416

OAKITE CLEANS

2000 Auto Parts For 78¢

THIS Auto Factory now uses Oakite for cleaning mineral oil from fenders, aprons, radiator shells, etc., before japanning, at a *fraction of former cost.*

The parts were formerly washed with a prepared alkali cleaner, and averaged 6 per cent rejects after japanning.

With Oakite materials, the rejects average only one in 800!

The actual cost of Oakite materials for cleaning each lot of 2000 parts is 77½ cents.

This Advertisement is one of a series based on actual occurrences.

But in computing the ***full economy*** in using Oakite materials, due consideration must be given to the saving effected in practically eliminating rejects.

May We Serve YOU Too?

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MANUFACTURED BY

OAKLEY CHEMICAL CO.

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BANTAM, CONN., U.S.A.

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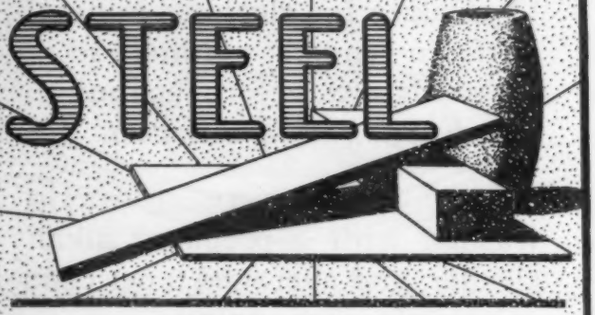

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Special Alloy Steel
Sheets and Bars
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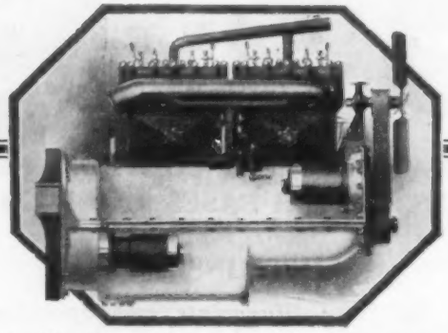

Outliving Expected Performance

Many engineers for large hauling concerns figure five years as the life of a truck. Consequently each year one-fifth of its cost is written off as depreciation. Records show that many Wisconsin-powered trucks continue to give reliable service for years after they no longer represent an investment on the books.

Wisconsin CONSISTENT Motors

are specified by manufacturers of better trucks and tractors because of their superior performance. Cost slightly more because of the greater care taken in their making. Each motor is run-in, torn down and rigidly inspected before re-assembly.

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is the ONLY all-metal tubing.
Titeflex tubing is inherently tight.
Titeflex can be furnished in long lengths.
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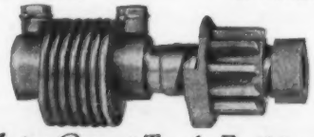
for ELECTRIC STARTERS — AUTOMATIC ENGAGING & DISENGAGING



194 Motor Car and Truck Builders Use It
ECLIPSE MACHINE CO., ELMIRA - N. Y. -

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Member American Gear Manufacturers Association

—the motive behind Crofoot Gears

There is a remarkably able corps of Crofoot engineers who will be glad to talk over your gear problems and suggest solutions

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for trucks, tractors and airplanes

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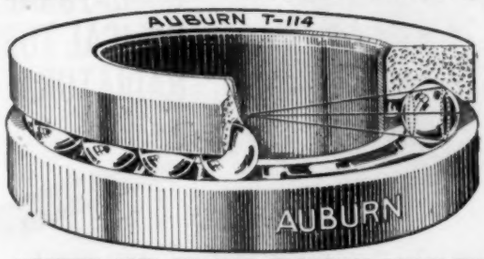

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Write for Bulletins or State Your Problem.
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AUBURN BALL BEARING COMPANY
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When your specifications include the Weston Model 354 Ammeter you are building prestige for your Company, because you are giving the motorist absolute satisfaction and the confidence he feels in knowing that his battery is safeguarded. The

Weston Model 354 Ammeter

The Watch Dog of Your Battery

is the instrument with which the motorist is familiar through our extensive campaign of National advertising.

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Weston Ammeters are used on a large percentage of the best domestic and imported cars. You are building a good car and we are building the best Ammeter for it. Why not let us come together and talk over the matter.

Weston Electrical Instrument Co.
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Our service organization is world-wide, covering the principal cities of this and other countries.

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Your Specifications

Let our Engineering Department help you work out some of your problems. They may be able to suggest the use of a particular style of cork part that will fully take care of your difficulty. There is no obligation attached to this offer—it's part of our service to automotive engineers.

Samples and prices free on request.

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AUTO MIRRORS

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have many desirable features. Detailed description of this Auto Mirror may interest you. May we send you literature?

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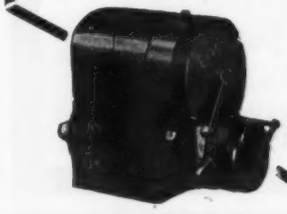
has so many points of superiority to ordinary ignition that the engineer who equips with it enhances the reputation of his car, truck or tractor.



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Chicago, 1469 S. Michigan Ave.
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We are building axle housings, brake drums, and other parts for the heaviest motor trucks ever built, and have ample capacity for still heavier.

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We solicit your inquiries.

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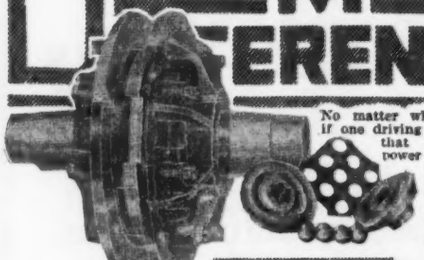
DORR MILLER DIFFERENTIAL



No matter what road conditions are, if one driving wheel has road traction, that wheel receives sufficient power to pull the truck out of mud, sand, gravel or snow. One wheel cannot spin in advance of the other. Truck cannot skid while turning corners. No gears are used in the Dorr Miller Differential. Write for complete details.

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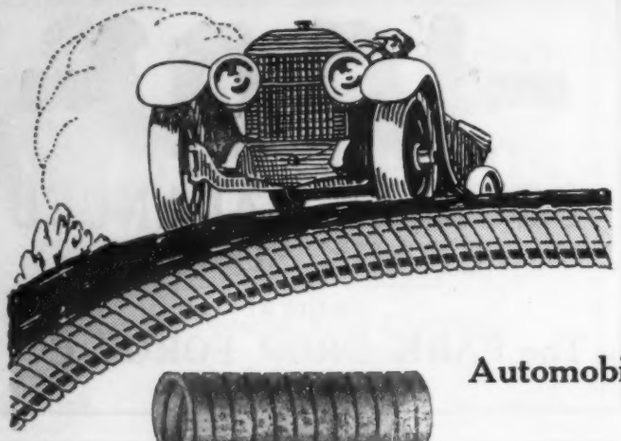
The 1920 Membership Roster has been mailed to the entire membership at the latest known address.

If the Roster has not been received, it probably is due to the fact that your address on our records is incorrect.

Members who have not received their copy of the Roster, or those who are not correctly listed therein, are urged to notify the office of the Society.

Your co-operation is necessary to maintain an accurate up-to-date mailing list.

MAY WE HAVE IT?



Auto-Steelflex
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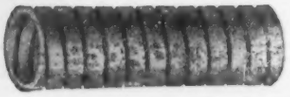

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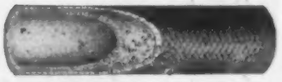

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Automobile Conduits and Fittings—Carburetor and Exhaust Tubing

Of the same superior quality as all National Products.

Bulletin 700, samples and full information furnished upon request.

National Metal Molding Co.

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The immediate engineering approval accorded Spicer Universal Joints and Propeller Shafts upon their introduction in 1904 has been validated by their record of fifteen years.

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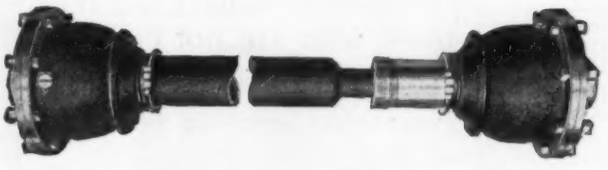
56 Ludgate Hill, London, E. C. 4

Spicer

UNIVERSAL JOINTS AND PROPELLER SHAFTS



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Made for
Constant, Dependable
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THE VAN DORN & DUTTON CO.
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Permit us to quote on parts purchased in productive quantities
ERIE SPECIALTY COMPANY
PRECISION SCREW MACHINE PRODUCTS
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They Outlast an Auto's Life

Users of G & K Link "V" Leather Fan Belts know that the same amount of power is transmitted by this type of belt when run slack as when run tight. This belt is a very radical departure from any previous type.

G & K Link "V" Belting, similar to the chain type of construction, minimizes the possibility of journal friction, even upon very light bearings. The links are assembled with rivets, except the master links, two or more of which are provided with each belt for the purpose of assembling. The master links are of screw, square-nut construction.

This nut, of special type, will not work loose, and is so constructed that the screw does not have to be headed over. This makes it possible to quickly and easily mount the belt on any drive. The G & K Link "V" Belt has great strength, positive grip, is noiseless in operation, has great flexibility and is practically indestructible.

Other products of the Automotive Division are universal joint boots, clutch leathers—square end, clutch leather—endless, steering wheel covers, flat fan belts, magneto coupling discs, special and standard crank holders, etc.

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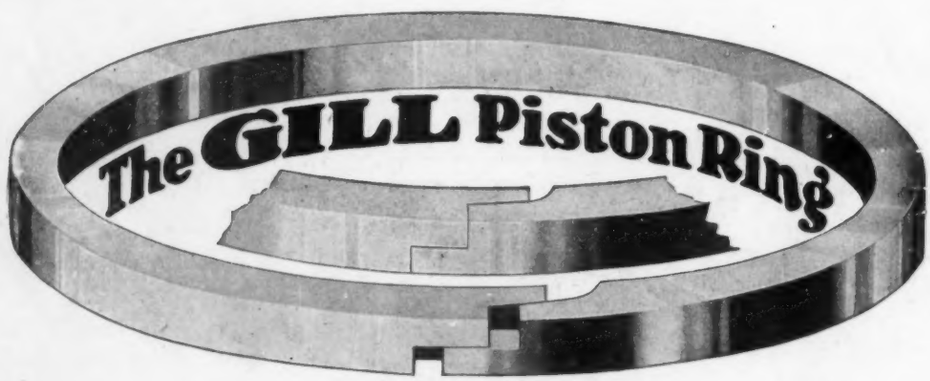
Oak Leather Tanners, Makers of Leather Belting & Leather Products

WORCESTER, MASS., U. S. A.



Simplicity

The outstanding feature of the Gill Piston Ring is the simplicity of its unique joint construction.

Gill Manufacturing Company

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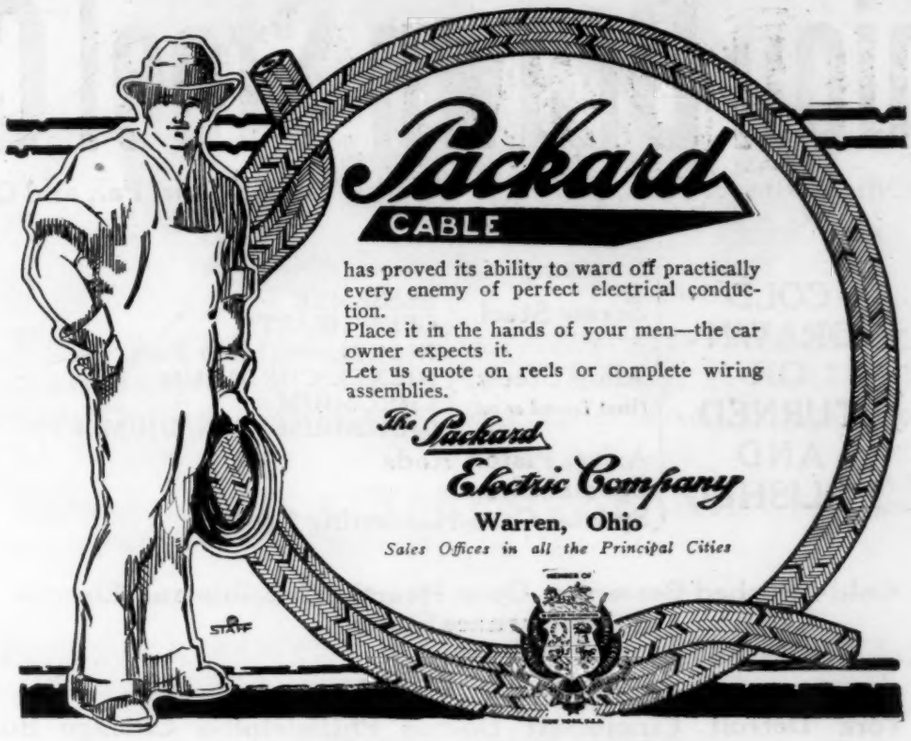
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Place it in the hands of your men—the car owner expects it.
Let us quote on reels or complete wiring assemblies.
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Raw Material to Exact Specifications or Small Parts to Order in Quantities

Small Parts for Automobiles

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We are specialists in handling large orders in short time and *exactly right*. We have the necessary facilities, experience, and dependability.

Our engineers are ready to help you in developing new designs. Get acquainted with Scovill Service.

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Union Drawn Steel Co.

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COLD DRAWN OR TURNED AND POLISHED

- Shafting
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Wherever Strom Bearings are mounted, noise and friction are eliminated.

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In passenger cars, trucks, tractors, machine shops—in fact, wherever a shaft turns, Strom Bearings have demonstrated their superiority.

Our engineers are ready to help solve your bearing problems.

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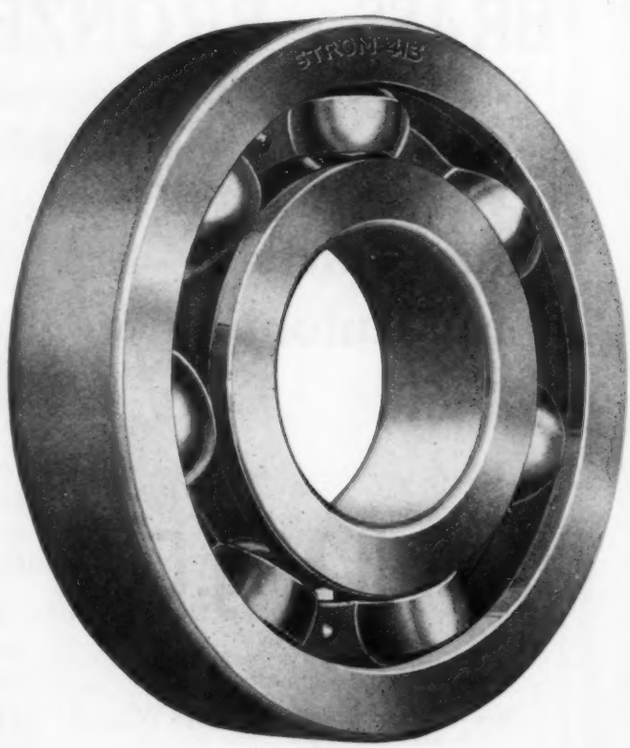
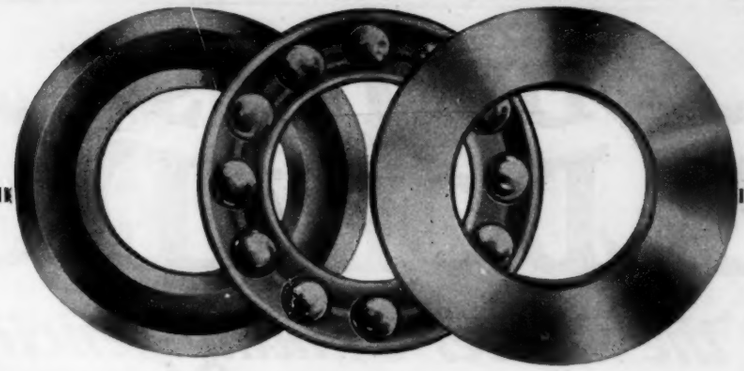
Strom BEARINGS





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manufacturers of "STAR" BALL RETAINERS
for Thrust, Magneto and Cup and Cone types
of Bearings.

Complete BALL THRUST BEARINGS (made to your requirements).

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Whether you buy normal alloy steel and do your own treating, or whether you buy annealed, heat treated or cold drawn alloy steels, you should avail yourself of the expert consultatory service which we offer.

The experience and training of our organization enables us to intelligently fulfill the requirements of alloy steel users.

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DIXON'S ELDORADO

"the master drawing pencil"

Draftsmen find Dixon's Eldorado a responsive medium in freehand sketching. And its clear, clean lines save both time and poise when you are making the working drawing.

SAMPLE OFFER

Write to us on your letterhead, tell us the kind of work you do, and we will mail you full-length free samples of your favorite leads. Also write for interesting pencil booklet—"Finding Your Pencil."

JOSEPH DIXON CRUCIBLE CO.
Pencil Dept. 95-J, Jersey City, N. J.

Canadian Distributors
A. R. MacDougall & Co., Ltd., Toronto

Made in 17 Leads —one for every need or preference

WILLIAMS' "AGRIPPA" TOOL HOLDERS

Better tools make better workmen—

And there are no better tools than Williams'

Ask for a copy of our Machinists' Tools Book

J. H. WILLIAMS & CO.

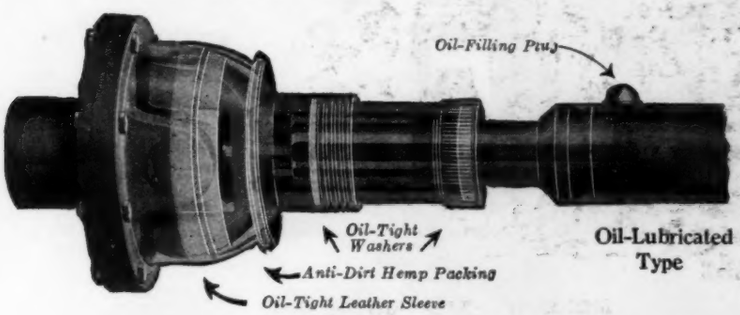
"The Drop-Forging People"

11 South Clinton Street, Chicago, Ill.
11 Vulcan Street, Buffalo, N. Y.
11 Richards Street, Brooklyn, N. Y

New M&E Universal Joint

for Oil Lubrication

Patented & Patents Pending



Oil-Lubricated Type

The "M & E" Oil-Tight Universal Joint has demonstrated its practicability in all temperatures under severe tests up to 15 degrees ± angle, without change or loss of lubricant or injury to leather sleeve.

Your layout should include this highly efficient unit.

We are still producing the "M & E" Grease Lubricated Universal Joints for those who prefer them.

Consult our engineers for particulars. Write now.

MERCHANT & EVANS Co.

NEW YORK PHILADELPHIA WHEELING
BALTIMORE CHICAGO
ATLANTA ST. LOUIS
CLEVELAND KANSAS CITY
LANCASTER DETROIT

COLUMBIA STEEL & SHAFTING CO.

MILLS GENERAL OFFICES
PITTSBURGH, PA.

COLD FINISHED STEEL PRODUCTS

Free Cutting Screw Stock -- "Columbia" Turned and Polished Shafting -- Axle and Alloy Steel Special Shapes

SALES OFFICES AND WAREHOUSES
BOSTON CLEVELAND DETROIT

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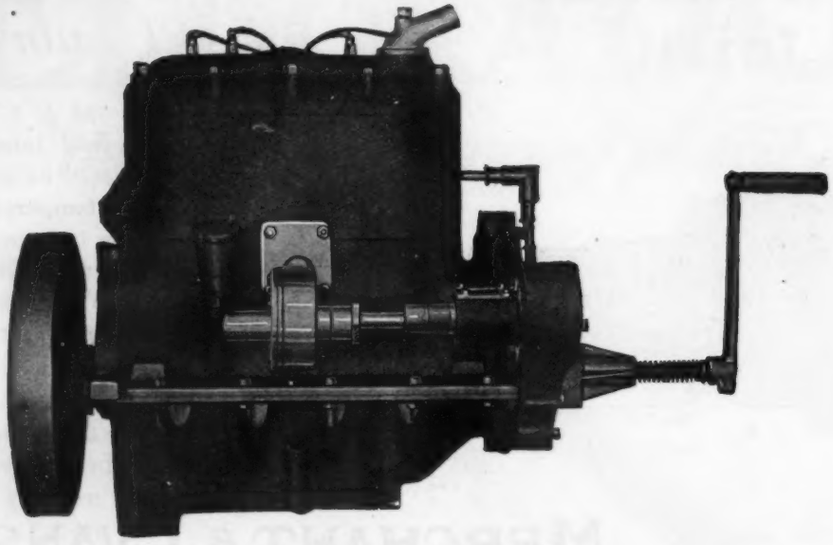
TRUCK AND TRACTOR MOTORS



MODEL H. "LMF" MOTOR

3¼ x 4½—4 cylinder—1⅞" diameter crankshaft
3½ x 4½—4 cylinder—2" diameter crankshaft

LIGHT MANUFACTURING & FOUNDRY COMPANY, Pottstown, Pa.

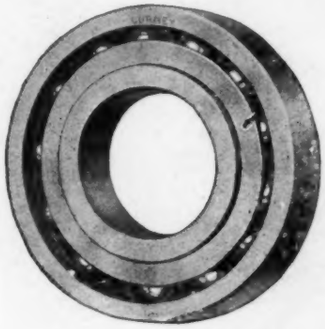
SMITH PRESSED STEEL FRAMES

We have one of the largest and best equipped plants in the world for passenger and truck frames of any design and capacity. Our facilities for Heat Treated Frames of which we are large producers are unsurpassed.

A. O. SMITH CORPORATION

MILWAUKEE

Detroit Office 708 Ford Building



GURNEY Bearings contain the maximum both in size and number of balls admissible in a single row. This is accomplished by the Gurney method of assembling.

As bearing capacity, other things being equal, is in direct ratio to both number of balls and size of balls, the advantage of this is too obvious to require comment.

Gurney Bearings go farther than using the maximum number of maximum sized balls. Their raceways are ground to a curvature closely approximating the curvature of the balls themselves. This greatly increases the capacity of each individual ball by increasing the areas of contact between balls and races.

In addition, Gurney bearings carry both radial and thrust loads on a single row of balls, simplifying machine design, and reducing weight of machine parts.

GURNEY BALL BEARING CO.

Conrad Patent Licensee

JAMESTOWN, N. Y.

GURNEY
BALL BEARINGS

New York to Raleigh-700 miles by airline-"Motor worked like a charm"

Curtiss

Member Manufacturers' Aircraft Association

THAT tells the whole story for it is the Curtiss power plant that "works like a charm" in all weathers and over all distances.

The Curtiss K-6 motor is used in Curtiss Orioles and Seagulls.

CURTISS AEROPLANE *and* MOTOR CORPORATION

Sales Office: GARDEN CITY, LONG ISLAND, N. Y.

Factories: Garden City, L. I., and Buffalo, N. Y. Flying Fields, Training Schools and Service Stations: Garden City, Atlantic City, N. J., Newport News, Va., Miami, Fla., and Buffalo. Dealers and distributors in all parts of the United States. Special Representatives in Latin America, Australia and the Philippines.

Gentlemen: Please show me how I can use a Curtiss Oriole in my business, and send me the Oriole booklet.

Name _____

Address _____ City _____

Occupation _____ State _____

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CERTIFIED MALLEABLE CASTINGS

THE AMERICAN MALLEABLE CASTINGS ASSOCIATION

ACA CERTIFIED

are of unusual

DEPENDABLE QUALITY

There are many places in which Certified Malleable Castings should be used where they are not now being used.

You may be employing steel, which is more expensive, but no more dependable; or gray iron, which has not the strength or elasticity—

CERTIFIED MALLEABLE CASTINGS—

are the result of years of study, experiment, research and application. They are a scientifically made, laboratorily tested product, with a minimum tensile strength of 45,000 pounds per square inch.

CERTIFIED HOLDERS, QUARTER ENDING MARCH 31, 1920:

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Our aim is a concentrated co-operative effort to make better castings. A report of any unfavorable experiences you have had will be appreciated by the association.

THE AMERICAN MALLEABLE CASTINGS ASSOCIATION

1900 Euclid Avenue

Cleveland, Ohio

Employers—When You Need Men

with engineering or executive training and experience

Write the Society of Automotive Engineers
Employment Service
29 West Thirty-ninth Street
New York City

We make **absolutely no charge** either to employer or employe for the employment service we render. This work is conducted for the benefit of S. A. E. members and companies in the automotive and related industries. Names and particulars as to salary, etc., are treated confidentially if desired.

Employes—When You Need a Job

or desire to make a change in occupation write us.

We are glad to be of service in helping you locate. **S. A. E. members** are granted free use of the Men Available Columns in the S. A. E. Journal.

Both Employers and Employes

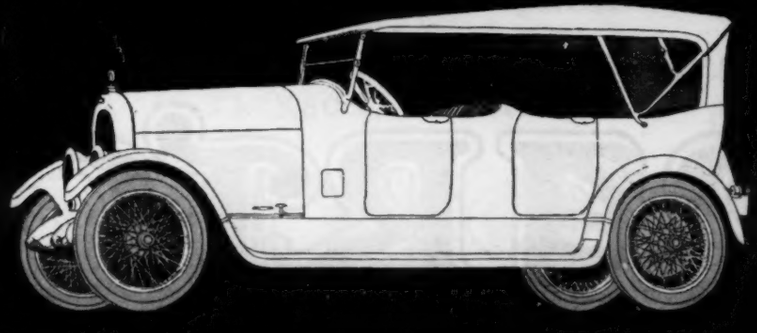
Should consult and use (without charge) the Men and Positions Available Columns beginning on page 50 in the Advertising Section of the Journal of the Society of Automotive Engineers.

THE quiet refinement of the Marmon car represents a harmony of mechanical excellences approved for quality performance. As might be expected Delco forms an integral part of this smooth unification of equipment. The prestige of Delco performance among starting, lighting and ignition systems is simply the customary tribute of the world to leadership gained through genuine worth.

THE DAYTON ENGINEERING LABORATORIES COMPANY
DAYTON, OHIO

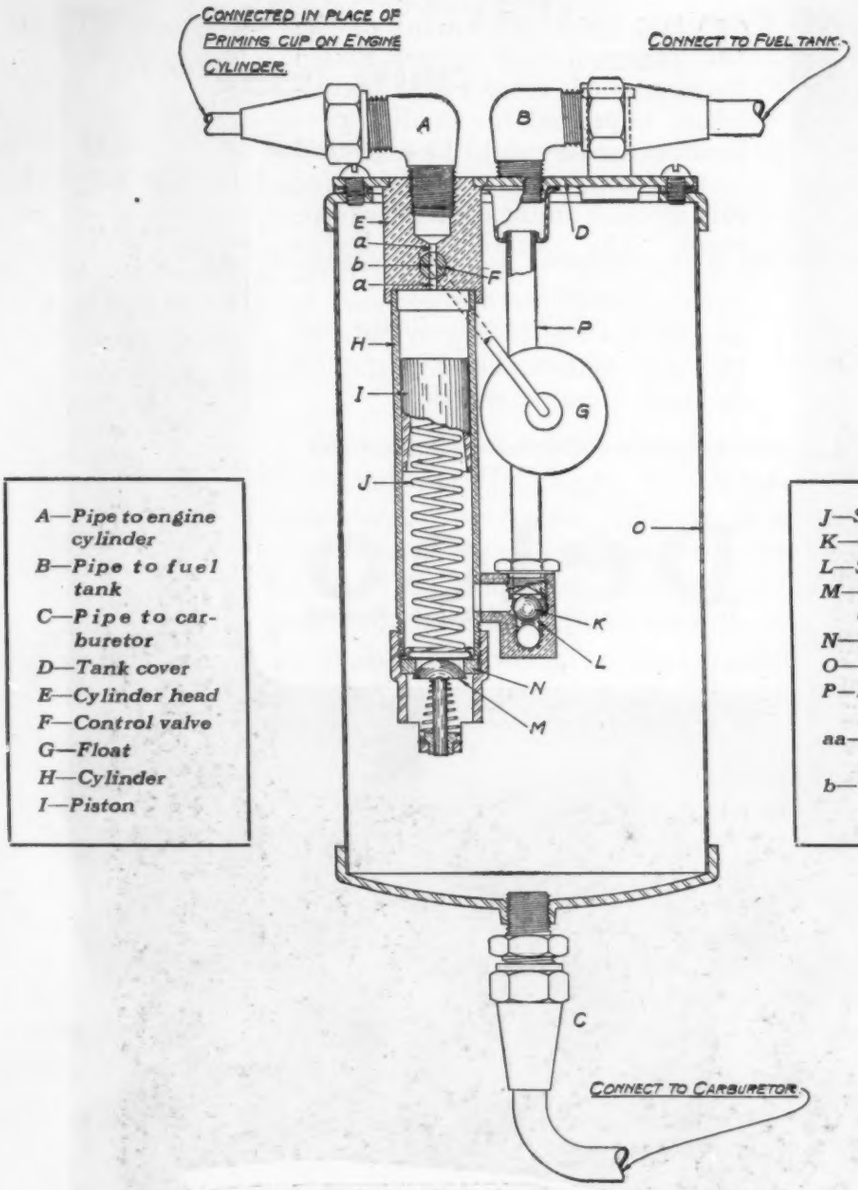
Delco

Starting, Lighting and Ignition Systems



MARMON

Announcing the New



A—Pipe to engine cylinder
B—Pipe to fuel tank
C—Pipe to carburetor
D—Tank cover
E—Cylinder head
F—Control valve
G—Float
H—Cylinder
I—Piston

J—Spring
K—Check ball
L—Seat
M—Lower discharge valve
N—Seat
O—Tank
P—Fuel supply pipe
aa—Control valve opening
b—Control valve opening

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SPARTON

Sparton Fuel Feeder

The Most Positive, Most Efficient, and Simplest Fuel Feeding Device Ever Designed

THE Sparton Fuel Feeder introduces a principle thus far never applied to a fuel feed—positive force generated in the combustion chamber so applied as to pump fuel in direct proportion to the motor's needs.

Instead of employing a vacuum created by suction from the intake manifold, the Sparton Fuel Feeder pumps direct from the supply tank the moment cylinder compression takes place.

Since compression furnishes the pumping power, the action of the Sparton Fuel Feeder is not only positive but it varies directly with the engine load. It does what no other fuel feeding device has ever done.

Reference to the mechanical drawing will make clear how the float and cut-off mechanism maintains a constant fuel level and thus insures a full fuel supply when it is needed most.

There can be no such thing as an exhausted supply on steep hills, in mud, or in sand, where the motor is laboring hard at reduced speed.

A condition wherein the vacuum tank principle raises the least fuel when the engine requires the most, can never happen in this device.

Again, all of the supply in the Sparton Fuel Feeder is always available, since no complicated valve mechanism can interfere.

Automotive engineers inside and outside the Sparton organization have tested the Sparton Fuel Feeder both in the laboratory and in practical operation over a long period and have proved its efficiency and practicability.

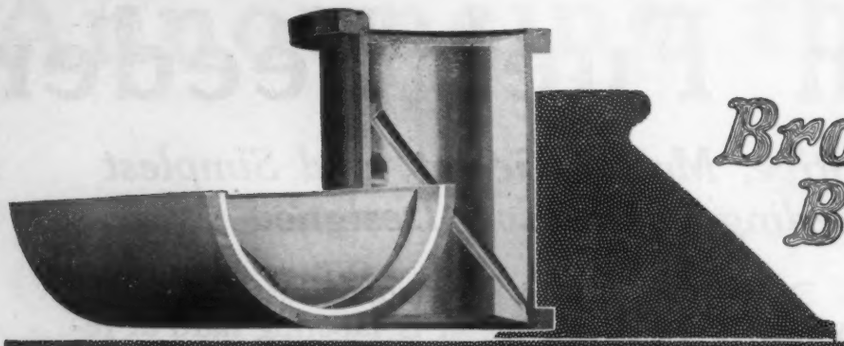
The Sparton Fuel Feeder is a small cylindrical tank, approximately the size shown in the drawing. It is to be mounted under the hood. It has few moving parts, is strong and durable.

For further information write to the Sparton factory.

THE SPARKS-WITHINGTON COMPANY
JACKSON, MICHIGAN

(166)

SPARTON



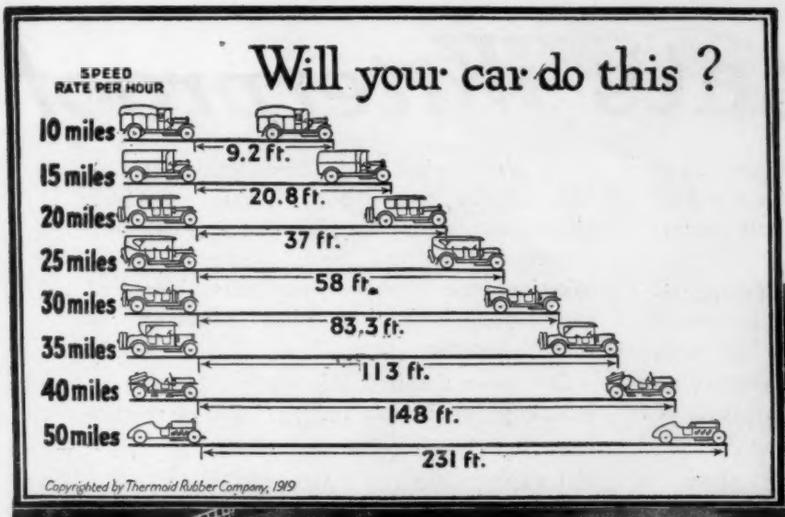
Bronze-Back Bearings

Softness and Strength Successfully Combined

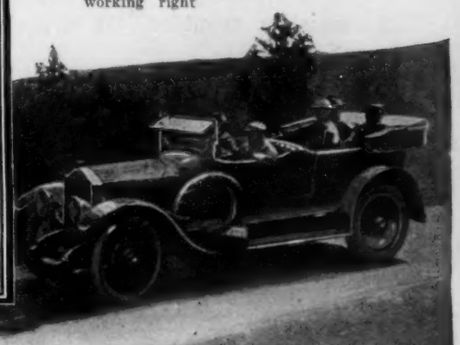
—in a two-part bearing—a babbitt lining rigidly united to a bronze backing by the Stewart Special Process. The result is the creation of a high-grade babbitt bearing of unequaled strength and wearing quality—a bearing precisely suited to automobile, motor truck, tractors, aircraft and electrical machine construction or mechanism of any kind involving the use of high-grade babbitt bearings.

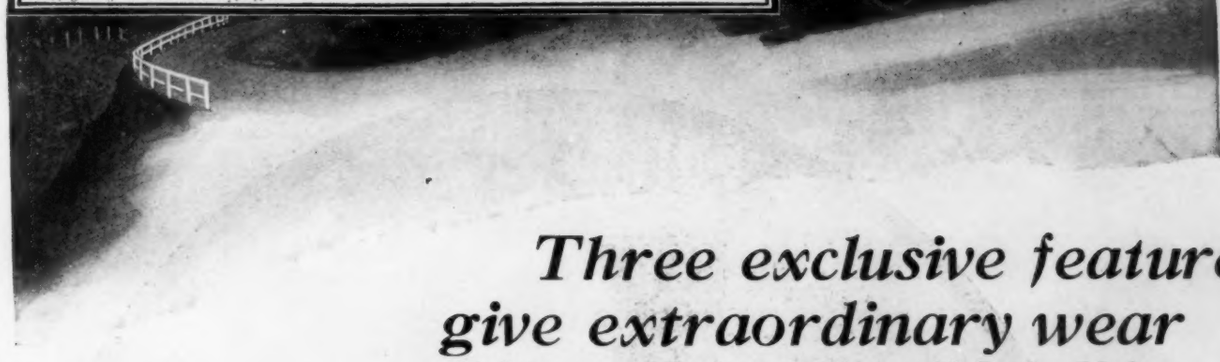
Stewart Mfg. Corporation
4500 Fullerton Ave. Chicago

Stewart



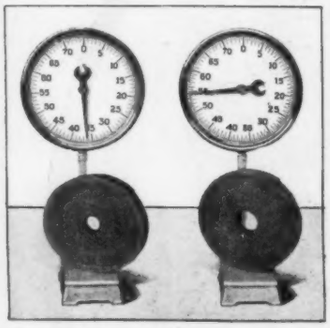
This chart, worked out by leading automotive engineers, shows how quickly a car should stop at various speeds if the brakes are in good condition and working right





Three exclusive features give extraordinary wear

Unique construction of Thermoid Brake Lining



100 ft. ordinary woven brake lining, wgt. 36 lbs. 4 oz.

100 ft. Thermoid Hydraulic Compressed Brake Lining, wgt. 54 lbs. 8 oz.

Thermoid has over 40% more material by actual weight

ORDINARY woven brake lining wears down quickly and unevenly. It grabs and slips after the first few hundred miles. Unless frequent adjustments are made, the driver can never be sure that his brakes will hold.

To ensure efficient brake action always, a brake lining has been perfected which wears down slowly and maintains its gripping power even when worn as thin as cardboard. This superiority of Thermoid is the result of three exclusive features in its construction.

1. *40% more material* by actual weight is used in Thermoid than in any woven brake lining.

2. *"Grapnalizing"*—an exclusive Thermoid process—makes the brake lining moisture proof and adds to its life to an unusual degree.

3. Powerful hydraulic presses force the *"Grapnalized"* fabric into a solid mass. This makes Thermoid far tougher and stronger. It makes an ideal surface for brake lining—a surface that cannot grab or slip—that has the correct "coefficient of friction" at all times.

Because of its long-wearing qualities and unfailing efficiency, the manufacturers of 50 of the leading cars and trucks have stardardized on Thermoid. More and more motorists are recognizing that Thermoid Brake Lining, made by these special processes, delivers the most in wear and hard service. To insure safe stopping they are demanding that their brakes be lined with Thermoid.

Standardize on Thermoid — the brake liningwith *40% more material* --that is *Grapnalized* and *hydraulic compressed*—that delivers the most in wear and safety.

Send for the new brake lining book. It contains valuable information about brakes which every engineer should know.

Thermoid Rubber Company

Factory and Main Offices: Trenton, N. J.

New York Chicago San Francisco Detroit Cleveland Atlanta Philadelphia Pittsburgh Boston London Paris Turin

Canadian Distributors:
The Canadian Fairbanks-Morse Co., Limited, Montreal

Branches in all principal Canadian cities

Thermoid Brake Lining

Hydraulic Compressed

Makers of "Thermoid-Hardy Universal Joints" and "Thermoid Crolide Compound Tires"

A Coil that's *Waterproof*

The coil of the new Westinghouse Type "SC" Standardized Ignition shuts the door to moisture troubles. It is entirely water-proof.

This coil is sealed in a water-proof composition tube, and is further protected by a steel base and a porcelain cap. While all parts are made to withstand high temperature as well as moisture, the internal temperatures of the coil are *exceedingly low*.

In the design and construction of this unit of the new "SC" Ignition System, there was need for just such skill and experience as has been accumulated by Westinghouse in more than thirty years of experience with insulation problems of every character.

For more detailed information be sure to get a copy of circular 1606. It will be mailed free on request.

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WESTINGHOUSE ELECTRIC

Westinghouse

STANDARDIZED IGNITION FOR AUTOMOTIVE VEHICLES

THERE is just one simple underlying principle that has held the distinct position of Bower Roller bearings unassailable among the better makers of motor transportation.

It is because they are constructed by a scientific principle to take the tremendous strains of sideway and the terrific shocks of load and road.

The result is practically endless wear and satisfaction that has a vital import on the life and service of car or truck.

BOWER
ROLLER BEARING CO.
Detroit Michigan

Exclusive Bower Features

Separate bearing surfaces for load and thrust. Parallel raceways. Self-aligning. Never need adjusting. Does not develop end thrust under loads. Will not bind or end-slip.

BOWER SAVES POWER

Your New Plant---*in Detroit*

Manufacturing space three times that of old plant. New equipment. Improved methods. Better service.

All to make, if possible, a closer relationship with S. P. customers—and all developed by the S. P. policy to make Drag Links, Starting Cranks, Rod Assemblies, with a little more character than is customary in parts not usually regarded as requiring a high degree of accuracy.

Carefully manufactured assembly parts pay the car builder.

Constantly increasing demand for parts so produced has made necessary the enlarged facilities.

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Cleveland, Ohio

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Tappets
Spring, King and
Tie Rod Bolts

No. 2
Bolt & Screw Plant
Cleveland, Ohio

Chassis Bolts
Special Bolts
Cap Screws
Etc.

No. 3
Hart Ave. Plant
Detroit, Michigan

Drag Links
Rod Assemblies
Starting Cranks
Etc.

No. 4
Conant Ave. Plant
Detroit, Michigan

Drag Links
Rod Assemblies
Starting Cranks
Etc.

The Steel Products Co.
A Department of Your Plant

SP ® STAFF

"The Ten-Test Truck"

Comparisons, tests and investigations are urged on truck buyers by the makers of the Gary truck.

Careful design, and the use of standard units of recognized quality are the basis of their confidence. The Gary Motor Truck Company believes as do fifty-four other well known motor truck builders, in the quality of Timken-Detroit Axles.

Abbott & Downing	Dorris	Master	Signal
Acason	Fageol	Michigan Hearse	Southern
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Diamond T	Locomobile	Service	
	Maccar		

*Front Axles

THE TIMKEN-DETROIT AXLE COMPANY
Detroit, Mich.

TIMKEN-DETROIT AXLES

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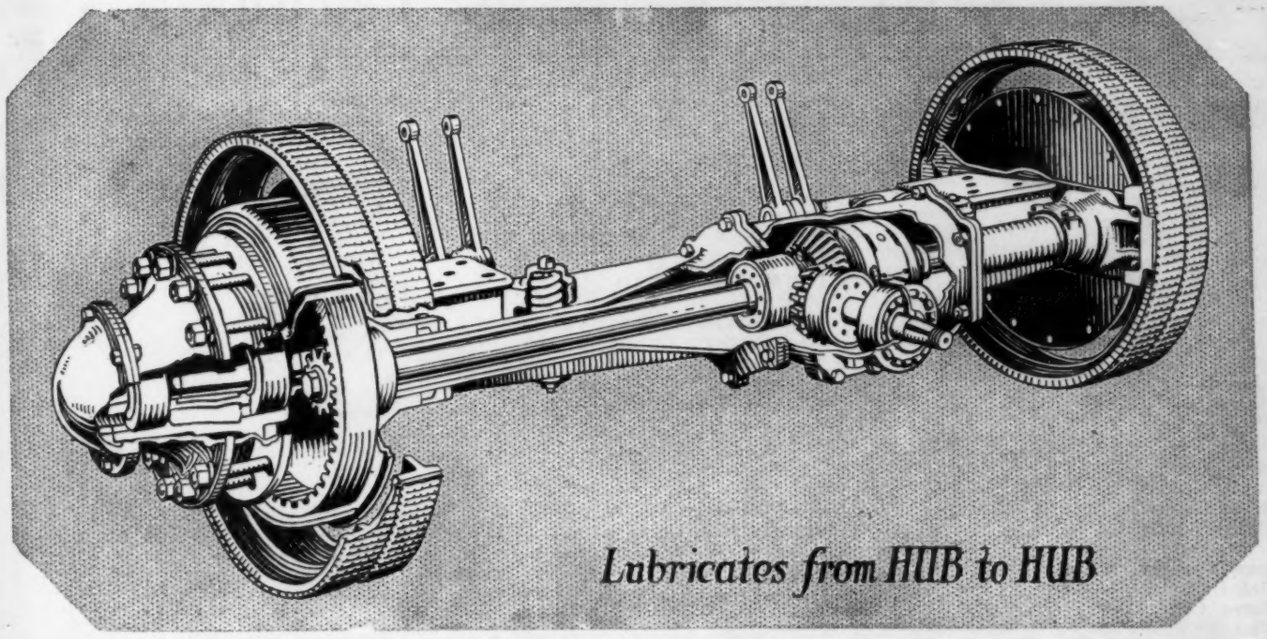

The Most Perfectly Lubricated Internal Gear Axle in the World

Kennedy supremacy in rear axle construction for motor trucks is due not only to quality but to a basic design that provides perfect lubrication.

Each moving surface is reached and all gears run in a drenching bath of oil, insuring smooth performance—and *tremendously prolonged life.*

Kennedy axles are more than 95 per cent built in the Kennedy shops.

1 ton **1½ ton** **2½ ton** **3½ ton**

Write for technical literature showing fifteen good reasons for Kennedy efficiency

THE HERO MANUFACTURING COMPANY

Incorporated 1883 **Philadelphia, Pa.**

Kennedy INTERNAL GEAR axles

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Light and Air

Comforts that add Quality

Production of exceptionally high quality gears is helped along in a great measure by light that gives clear vision and air that promotes bodily comfort of the workers.

At Warner Gear these factors belong naturally in the plan to help the skilled worker produce a gear assembly unquestioned in quality—unequaled in service.

WARNER GEAR CO.

MUNCIE INDIANA

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G&O

Square Fin Tubular Radiator

Simply making the fins square instead of round adds 20% to the radiating surface. The cooling efficiency of the radiator is increased in proportion. Manufacturers are adopting this radiator for heavy duty models because it is built with common sense throughout, for hard work.

The G & O Manufacturing Company

New Haven **Connecticut**

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Where You Can't Miss It

On the garage door, on the wall, or some place where you and your trade can't help seeing them, have these four figures, 1-2-8-5.

Let them stand as a reminder of the point where battery charge ought to be kept for long battery life, for protection against freezing, for assurance of a quick start, bright light and hot spark.

Remind your customer that it only takes a few minutes to read the charge of the battery with a hydrometer, and it is the only way the car owner can depend upon for accuracy.

The rule applies to the Still Better Willard Battery with Threaded Rubber Insulation as well as to any other. The thing that makes Threaded Rubber different from ordinary insulation is its ability to stay on the job as long as the battery serves. It does not need to be replaced while ordinary insulation almost always has to be replaced at least once during the life of the battery.

Willard Service

THREAD W RUBBER

Willard STORAGE BATTERY

Willard Threaded Rubber Insulation

CLEVELAND, OHIO

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And Now 35 MANUFACTURERS

TWO months ago we announced the adoption of Gray & Davis starting-lighting systems, starting-lighting-ignition systems, or lamps as standard equipment by twenty-eight American manufacturers of passenger cars and trucks. To-day the number has grown to thirty-five.

IT is significant of a better trend in the automotive industry, that the great tide of manufacturing practice is swinging toward reliability and quality, as exemplified in Gray & Davis equipment, on a constantly growing number of automobiles.

GRAY & DAVIS, INC. BOSTON, MASS.

GRAY & DAVIS

Starting – Lighting – Ignition – Lamps

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contains an alphabetically arranged classification of various products of interest to members of the Society.

The listings which represent the products of well-known companies that advertise regularly in the Journal are designed to cover, as far as possible, the needs of the different branches of the automotive industry.

Members in search of possible sources of supply for parts or materials are referred to this section as a convenient means of meeting their requirements.

This section contains approximately 260 headings, covering the products of 145 firms.

It is found in this issue on pages 98, 100, 102 and 104.

EATON

THE DAY IS NOT FAR DISTANT WHEN THE NAME, EATON, WILL MEAN AS MUCH TO THE PROSPECTIVE MOTOR CAR OR MOTOR TRUCK BUYER AS IT NOW DOES TO THE ENGINEERING PERSONNEL OF THE AUTOMOTIVE INDUSTRY.

THE EATON AXLE COMPANY, CLEVELAND, OHIO

THE AXLE DIVISION OF THE STANDARD PARTS COMPANY

OTHER DIVISIONS ARE: THE PERFECTION SPRING COMPANY, THE BOCK BEARING COMPANY AND THE STANDARD WELDING COMPANY

AXLES